HEZ Water Cycle Management Strategy

Hydrology, Water Quality, Soils, Groundwater and Water Cycle

Prepared for
HEZ Nominees

Prepared by
EDAW
Ecological Engineering Practice Area

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EXECUTIVE SUMMARY

This report presents an integrated water cycle management strategy for the Hunter Economic Zone and responds to the requirements of Department of Planning Director General requirements. The report also describes the impacts of the Precinct 1 industrial development and broader HEZ development.

The proposed greater HEZ will replace 900 ha of forest with a mix of urban development for industrial purposes. The potential impacts on the natural runoff regime and ground water processes are great but will be managed through the principals of Water Sensitive Urban Design which utilises an alternative approach to traditional stormwater management to achieve the following outcomes:

- Protecting habitat by preserving the geomorphic form of waterways;
- Protecting downstream water quality through the control of industrial pollutant generation and reduction of typical urban stormwater pollutant loads;
- Protecting downstream development from increased flood flows;
- Reducing potable water volumes imported from external catchments through demand management and stormwater harvesting; and
- Reducing the generation of wastewater and reducing impacts at the point of discharge to receiving waters.

Potential and Residual Impacts of the HEZ

The HEZ site is crossed by intermittent creeks which drain to Wallis and Swamp Creeks that in turn feed downstream wetlands and supply water for agriculture. Many of the creeks within the HEZ Site are in good condition providing important frog habitat however several creeks are actively eroding due to hydrologic changes associated with historical mining on the site. This erosion continues to propagate upstream during high flow events which is a source of sediment pollution to downstream waterways and requires intervention to prevent further degradation of in stream habitats and ongoing water quality issues downstream. A program of in-stream channel Improvements are proposed to halt the active erosion of waterways and improve the existing condition of streams protecting these habitats from further impacts.

Soils across the site typically comprise heavy clay overlaid by a 100 mm horizon a sandy top soil. The soils are derived from weathered siltstone, sandstone and coal have been identified as highly erodible (Hunter Central Catchment Management Authority, 2001) while the clay beneath is particularly dispersive. These soil types are prone to erosion when topsoil is removed by storm flows exposing dispersive clay soils beneath. Subsequent swelling of the clay causes creek banks slump. Other areas of the site are highly porous such as those underlying the Kurri Sands lowland forest. Mining operations have left large deposits of coal mining spoil which are thought to contribute to high nutrient loads in downstream waterways. The proposed industrial development within the Site has the potential to introduce soil contamination associated with illegal dumping, poor site management and irresponsible practices. Stormwater treatment devices required on all sites within Precinct 1 and the greater HEZ will partially intercept stormwater borne pollutants, however these systems are designed to treat stormwater pollutants associated with frequent rainfall (heavy metals, sediments, litter and nutrients) and the threat of significant chemical spills must be controlled with industrial site design (physical isolation of chemicals with bunds and roofed work areas), site management (spill management and proper chemical handling) and operator education aimed at reinforcing the link between on site activities and environmental impacts.

Geotechnical investigations have identified the local groundwater table is some 10 to 20 m below ground. Areas of high infiltration have been recorded, and creeks are likely to be fed from localised and transient perched water table occurring after rain. The impact of underground mine workings on local and downstream groundwater tables is not well understood. The increase in impervious areas associated with Precinct 1 and the greater HEZ development have the potential to reduce groundwater infiltration rates at the local scale, however given the scale of the development within the greater catchments, Precinct 1 and the greater HEZ site are not expected to alter the regional groundwater table and will therefore have only a marginal impact on groundwater recharge.

The existing water quality of local creeks is poor. Monitoring undertaken during previous studies has identified high nutrient and sediment levels within the site and downstream waterways. There are no obvious point sources of pollutants, but high levels of nutrients, turbidity and salinity are presumed to occur from existing urban runoff, the presence of mining wastes within the catchment, historical septic tank use and effluent discharge from the Kurri Kurri Waste Water Treatment Works. Stormwater runoff from Precinct 1 and the greater HEZ development has the potential to exacerbate water quality problems, but the risk of this will be significantly reduced through stormwater treatment across the site.

Management of Impacts of the HEZ Through WSUD

Without proper management, the proposed and existing industrial development within Precinct 1 and the greater HEZ Site could potentially exacerbate local erosion, flooding and water quality, and further degrade protected conservation areas. The HEZ Water Cycle Management Strategy establishes a series of best practice stormwater management objectives to protect aquatic and groundwater environments from the potential impacts of industrial development. The strategy is proposed to be implemented via the draft Statement of Commitments requiring all development within the HEZ estate to be designed in accordance with the requirements of the Strategy.

A program of in-stream channel Improvements are proposed to halt the active erosion of waterways and improve the existing condition of streams protecting these habitats from further impacts associated with the proposed HEZ development.

By implementing a strategy of stormwater harvesting on individual lots and at the cluster scale, potential runoff volumes associated with development will not reach creeks and will there by preserve the ephemeral hydrologic regimes of local creeks and frog habitat. Where existing development or proposed development cannot meet stormwater harvesting and reuse targets, infiltration of treated stormwater will be implemented to recharge groundwater and reduce runoff volumes.

During times of heavy rain swales and detention storages will act as buffers that slow the arrival of stormwater to local creeks to protect them from erosive flows. Where the underlying soils are conducive to infiltration, groundwater recharge will be encouraged through French drains and infiltration areas. This will replenish base flow concentrations and reduce stormwater loads to creeks.

Typical urban stormwater pollutants (suspended solids, litter, oils, heavy metals, nitrogen and phosphorous) will be managed to meet pollution control targets set by the Department of Environment and Climate Change and adopted by the Growth Centres Commission for development in Sydney’s north west and south west growth centres. These reduction targets represent current best practice stormwater management and are more stringent in the control of sediment and phosphorous than those commonly adopted in NSW.

Attainment of the pollution control targets for both private and public areas is likely to be through the use treatment trains which may include:

- Swales and bioretention pods

- Bioretention with pre-treatment from sedimentation areas.
- GPTs and wetlands.

Combinations of bioretention, wetlands and gross pollutant traps will be incorporated into lot and road designs to meet best practice management pollutant reduction targets adopted to protect more significant waterways across the state. Stormwater pollutant loads will increase post development of the site, however these pollutant export events will be associated with storm events when significant flushing of downstream waterways is occurring. Impacts are not considered to be significant given the existing apparent poor water quality of receiving waters near the site and the relatively infrequent occurrence of pollutant events.

On site detention basins will be incorporated into lot design to attenuate flood flows and prevent the development from flooding downstream areas. No net increase in the 100-year discharge will result from the sites development.

The intermittent waterways that cross the site flow only after heavy rain and are likely fed by localised and intermittent perching of the ground water table. The permanent groundwater level is some 10 to 20 m below ground surface and does not contain express itself as permanent waters within the site boundary. Downstream wetlands may be Groundwater Dependant Ecosystems during dry periods, and changes to the infiltration within the site (if any) are considered to have an negligible effect on the site is considered .

The proposed development will reduce typical volumes of potable water imported from external catchments through demand management and stormwater harvesting at the lot scale. The HEZ Authority is in a good position to influence the location of developments and administer the sharing of harvested stormwater where water intensive industry can use underutilised stormwater from neighbouring lot/s.

The design of lots to exclude stormwater from work areas will relieve the need to discharge captured water to the sewer and in so doing will reduce the generation of wastewater. This will provide environmental benefits in so far as reducing impacts at the point of wastewater discharge.

Proper implementation of the Strategy will deliver a sustainable outcome to the HEZ that is supported by sound technical guidelines and practical implementation at each lot without unreasonable impost to the developer.

Contents

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1 INTRODUCTION

This report presents an integrated water cycle management strategy for the Hunter Economic Zone and responds to the requirements of Department of Planning Director General requirements.

The Hunter Economic Zone (HEZ) covers an area of approximately 900 ha of forest rezoned for industrial development. The area is located immediately south-west of Kurri Kurri in the Hunter Valley. Most of the site is currently undeveloped, though mining has taken place in parts of the site in the past. The site is currently covered with a good stand of eucalypt and paperbark forest estimated to be 40 to 60 years old. The HEZ area drains via several ephemeral tributary creeks to Swamp Creek and Wallis Creek. The creeks are known to be highly erodible and provide habitat to the vulnerable and endangered flora and fauna species.

Without proper intervention, stormwater runoff from the proposed development has the potential to significantly impact on the natural hydrology of local creeks, the ecology of riparian corridors and the quality of downstream waterways. Increased runoff rates, runoff volumes and stormwater pollutants must be managed to preserve these natural assets.

Stormwater will be managed in an integrated manner along with other urban water streams. The establishment of the HEZ will include the provision of potable mains water and wastewater reticulation. Water supply may be provided from the existing Stoney Pinch reservoir or may require additional capacity. Wastewater treatment may be provided at either Kurri Kurri or Farley Wastewater Treatment Works, however capacity upgrades may be required.

This report has been prepared to respond to the Department of Planning Director General's requirements relating to soil and water quality management under Section 75 of the *Environmental Planning and Assessment Act 1979,* which are:

> *the Environmental Assessment shall include details of the proposed stormwater management, water cycle management and surface water quality impacts associated with the proposed facility, existing development proposals and likely future development in Precinct 1 and the broader HEZ site.*

The proposed management strategy described in the following chapters will achieve significant reductions in the potential impacts associated with industrial development by:

- Protecting habitat by preserving the geomorphic form of waterways;

- Protecting downstream water quality through the control of industrial pollutant generation and reduction of typical urban stormwater pollutant loads;
- Protecting downstream development from increased flood flows;
- Reducing potable water volumes imported from external catchments through demand management and stormwater harvesting; and
- Reducing the generation of wastewater and reducing impacts at the point of discharge to receiving waters.

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2 STORMWATER, THE WATER CYCLE AND SURFACE WATER QUALITY MANAGEMENT

The integration of the urban water cycle, often referred to as Water Sensitive Urban Design (WSUD), is concerned with the interactions between the urban built form (including urban landscapes) and the urban water cycle - potable water, wastewater, and stormwater.

2.1 WATER CYCLE MANAGEMENT AND WATER SENSITIVE URBAN DESIGN

The principles of integrated water cycle management or Water Sensitive Urban Design (WSUD) are presented in Figure 1, illustrating how benefits to one element can often have flow on benefits to other elements of the water cycle. These principles are centred on the protection of aquatic environments through the following:

- Reducing potable water demand through water efficient fittings and appliances and rainwater harvesting.
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or to release to receiving waters.
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to receiving waters.
- Achieving flow attenuation from new developments to mitigate downstream flood impacts and prevent stream erosion.
- Using stormwater in the urban landscape to maximise the visual and recreational amenity of developments.

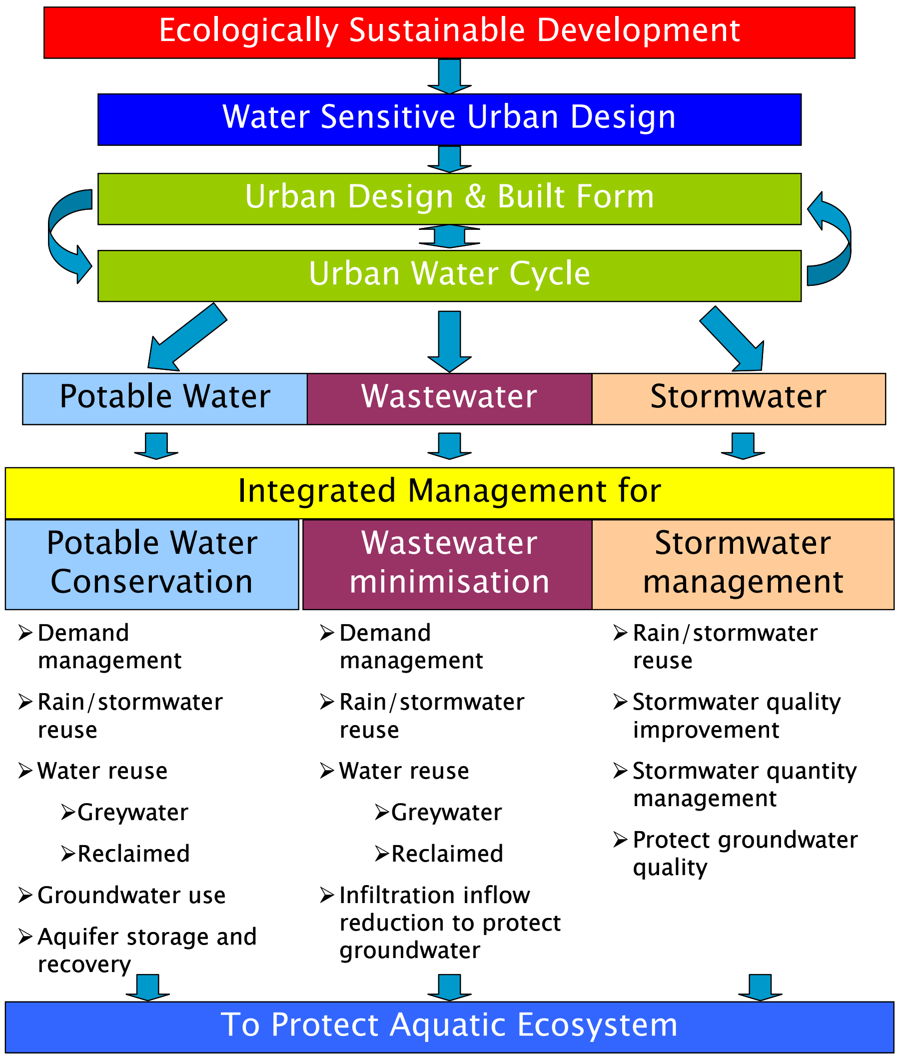

Figure 1 – Water cycle management framework

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3 NATURE OF THE EXISTING SITE

The existing HEZ site supports habitat of rare stands of forest and vulnerable fauna. The proposed change from woodland forest to an industrial land use will increase runoff generated on the site. Without intervention, runoff volumes, flow rates and stormwater pollution could potentially alter the hydrologic regime of local waterways, degrade habitat values of the site and contaminate downstream waterways.

3.1 CLIMATE AND HYDROLOGY

The rainfall gauge at the Cessnock Post office indicates that the HEZ receives an average rainfall of 748 mm per year. Rainfall occurs throughout the year with the majority occurring in summer. The Hebburn Dam catchment is ungauged and the nearest stream flow gauge in Fisheries Creek does not present a good opportunity for calibrating a hydrologic model. However, due to the existing forest and pervious top soils it is expected that approximately 20% of rainfall falling on the site will become runoff with the remainder being intercepted by plants or lost to groundwater. Monthly rainfall and evaporation at HEZ are presented in Figure 2.

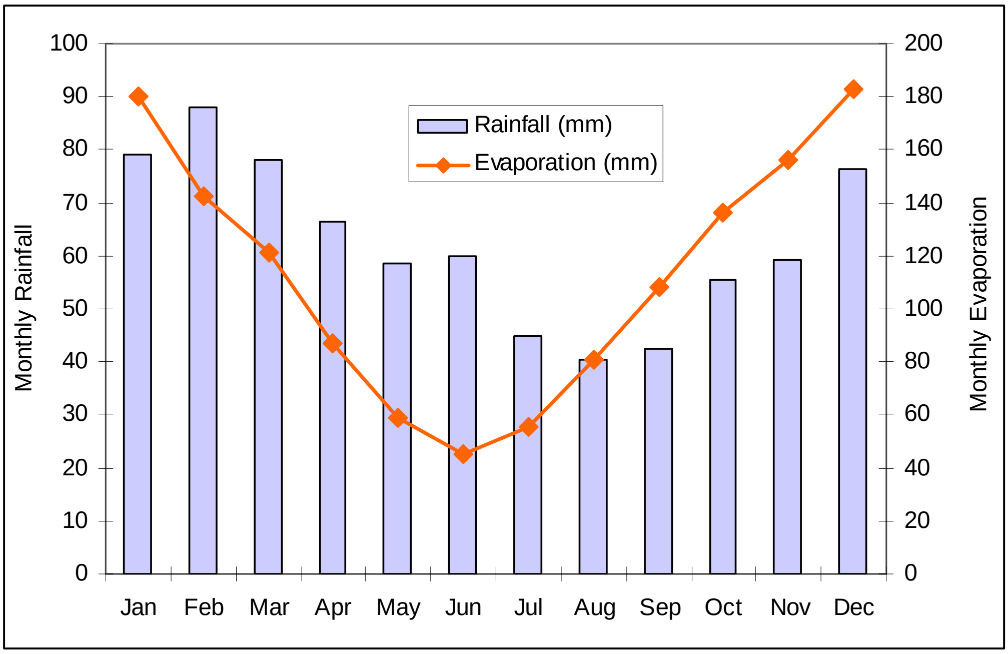

Figure 2: Climate data at HEZ

3.2 SOILS AND GROUNDWATER

Soils across the site typically comprise heavy clay overlaid by a 100 mm horizon a sandy top soil. The soils are derived from weathered siltstone, sandstone and coal have been identified as highly erodible (Hunter Central Catchment Management Authority, 2001) while the clay beneath is particularly dispersive. These soil types are prone to erosion when topsoil is removed by storm flows exposing dispersive clay soils beneath. Subsequent swelling of the clay causes creek banks slump. Other areas of the site are highly porous such as those underlying the Kurri Sands lowland forest. Mining operations have left large deposits of coal mining spoil which are thought to have contributed high nutrient loads in downstream waterways.

Geotechnical investigations have identified that where present, groundwater is located at depths of 10 to 20 m below ground surface. Investigations by Douglans Partners within the Alluvial profile did not encounter groundwater which was attributed to underground coal seams and coal mines beneath the site. It is expected that localized a perched groundwater table may form following rain, but is likely to be transient due to fissures and mines. Groundwater base flows would flow north towards the Heburn Dam which experiences large water level fluctuations consistent with rain and prolonged dry spells. The water level within the dam is not expected to be an expression of ground water.

No Groundwater Dependant Ecosystems (GDEs) occur within the site, but the Wentworth Swamps and many wet swamps are located downstream of the site along Swamp and Wallis Creeks. The site is considered to contribute a very small fraction of inflows to these systems which are likely to be predominantly fed by surface water flows from the greater Swamp and Wallis Creek catchments.

3.3 ECOLOGY AND GEOMORPHOLOGY OF WATERWAYS

A network of shallow creek lines cross the HEZ feeding the waterway that forms the Hebburn Dam and two watercourses to the East and West. The creeks are naturally ephemeral streams, which support shallow pools in dry times. These pools are important habitat features as they are a permanent water source between infrequent streamflow events providing important habitat for the vulnerable Green Thighed Frog. Between pools, the natural creeklines are vague; flows would spread over a broad area rather than following a defined course. Wetter forest, including the Hunter Lowland Redgum Forest, can be found in these areas.

The creeks on site are known to be highly erodible and there is evidence that historical erosion associated with the sites mining history is propagating upstream. Erosion can be triggered by increased flows resulting from land use change. Within the vicinity of Stage 1, sections of the main Hebburn Dam waterway have been severely eroded. This appears to have commenced several decades ago most likely while the site was cleared and mined. Now that the forest has re-established, the runoff rates will have returned to a more natural state. Despite this, erosion probably occurs periodically, associated with major stream flow events and is still propagating upstream delivering loads of sediment throughout the 3 waterways.

Erosion will potentially be exacerbated by the proposed development without flow management and creek stabilisation works. Protection of Green Thighed Frog habitat requires that channels are not allowed to become incised and floodplain wetting is maintained.

Figure 3: Undisturbed section of Hebburn Dam tributary, where flows would spread over a wide area

Figure 4: Large pool in Hebburn Dam tributary

Figure 5: Section of Hebburn Dam tributary that has eroded some time ago and re-stabilised to some extent

Figure 6: Section of Hebburn Dam tributary that is undergoing active erosion

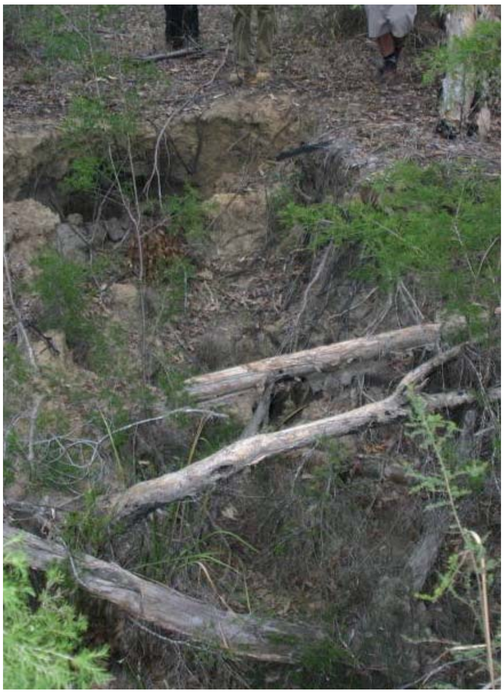

Figure 7: Section of active head cut on the southern tributary in Precinct 1

3.4 EXISTING WATER QUALITY OF DOWNSTREAM WATERWAYS

Several previous studies have been undertaken to assess the water quality of Swamp and Wallis Creeks and are summarised in PB (2004). The studies have generally found that:

- Salinity within the Wallis Creek is often high despite no obvious point source. Derelict mines and saline soils were suggested as potential sources of the dissolved solids.
- Background turbidity levels in Wallis Creek are high, and are diluted by the Kurri Kurri Waster Water Treatment Works (WWTW)
- Nutrient levels in Swamp and Fisheries creek are high and exceed ANZECC trigger values for the protection of aquatic environments
- Total Phosphorous (TP) and Total Nitrogen (TN) levels in Swamp Creek are high and exceed ANZECC trigger values for the protection of aquatic environments. This is attributed to WWTW effluent and urban runoff.

Water quality monitoring of several sites around the HEZ was undertaken as part of a previous study by Parsons Brinkerhoff (PB, 2004) to establish existing base line water quality for the site. The study sampled surface water quality in Swamp Creek, the Hebburn Dam within the HEZ site and a tributary of Wallis Creek over a six month period and found water quality to be typically poor despite the recovered forest across the site. Monitoring revealed that TP and TN to be consistently high with median values above default ANZECC trigger values. Turbidity levels generally exceeded the Department of Environment and Conservation (DEC) Interim Environmental Objectives (1999) guideline value at all monitoring locations. Faecal coliform levels exceeded the ANZECC (2000) guidelines default trigger value for agricultural water use on several occasions.

The report speculates that the high levels of nutrients and poor water quality could be a result of the presence of mine tailings on site, effluent irrigation within the catchment, historical use of septic tanks upstream of the site, urban drainage from adjacent suburbs and interaction of mine waters with surface water. In light of subsequent geotechnical investigations the interaction of mine waters with surface water on site is unlikely. The monitoring period is most likely too short to identify if water quality is typical of the area or influenced by drought conditions during the monitoring period.

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4 PROPOSED DEVELOPMENT AT HEZ AND POTENTIAL IMPACTS ON WATER CYCLE

The proposed change from woodland forest to an industrial land use will increase runoff and stormwater pollutants generated on the site which have the potentially to alter the hydrologic regime of local waterways, degrading the habitat values of the site and impacting downstream water quality.

4.1 EXISTING HEZ INDUSTRIAL DEVELOPMENT AND DEVELOPMENT APPLICATIONS

Several existing developments and proposed developments have been designed to manage stormwater quality and flood flows, but do not address stormwater volume, runoff frequency and flow rate management of minor storms. There is still potential to manage these hydrologic impacts through infiltration areas. Should the underlying soils exclude this option, impact on stormwater volumes and flow rates downstream water courses are minor given the proportion of catchment that these developments represent.

Existing roads have been designed in a similar manner and while localised low flow rates will increase without additional intervention impacts will be minor and localised.

4.2 PROPOSED HEZ INDUSTRIAL DEVELOPMENT

The proposed HEZ development covers approximately 870 ha of forest draining to Swamp Creek and Wallis Creek via three ephemeral waterways. A map of the site and catchment is presented in. Lot sizes propose within the Stage 1 Precinct of HEZ are in the order of 2 ha with some larger lots being proposed under Development Applications. These lots will comprise managed vegetation zones with industrial activity areas accounting for approximately 80% of the lot area. Sites within will discharge to adjacent drainage infrastructure being either:

- verges at the front of lot on the upgrade side of roads, or
- retained waterways or drainage easements at the back or side of industrial lots.

Stormwater within each lot will be managed via a combination of means that will mitigate the impacts of development on the adjacent Environmental Protection Zones. Runoff from undeveloped areas and management zones will be of a sufficient quality and quantity to discharge to local waterways untreated.

Similarly road runoff will be managed to ensure the impacts of increased runoff and pollutant loads do not impact the adjacent Environmental Protection Zones. Existing roads are be drained by a combination of pit and pipe drainage, and a combination of gutter and bio-swales along proposed roads. Frequent runoff from lots and roads will not mix until discharged to waterways.

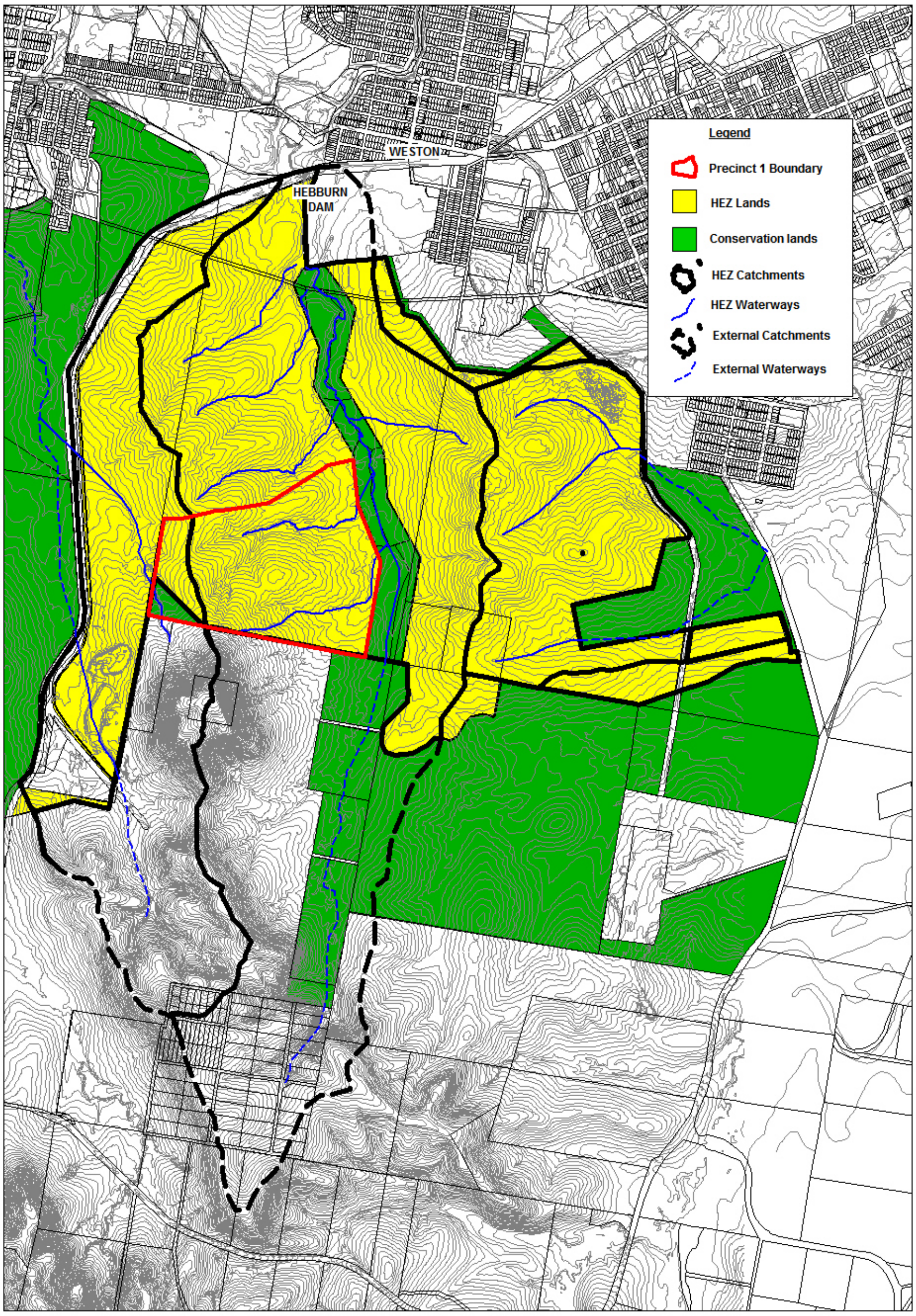

Figure 8: Catchments, Waterways and Land Use Planning Zones of HEZ

4.3 POTENTIAL HYDROLOGIC IMPACTS

Increased impervious areas associated with the proposed development will increase volumes of runoff generated on the site. These effects are a combination of increased imperviousness, a significant reduction in infiltration and evapotranspiration processes from clearing and paving. Figure 9 presents a comparison of runoff time series generated from 10 ha areas of forest and industrial development.

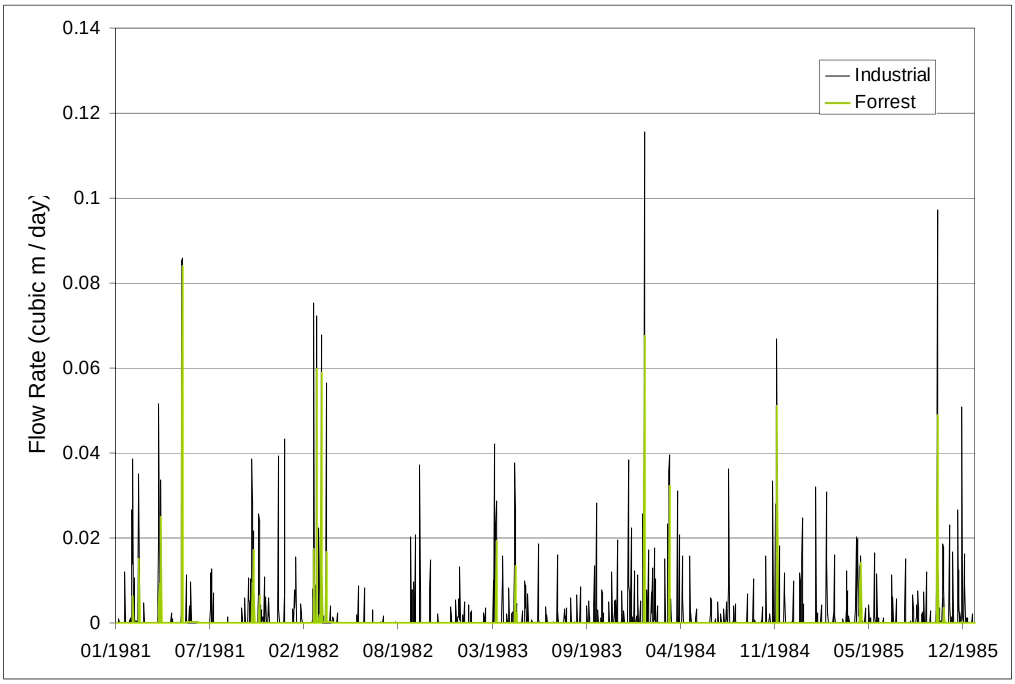

Figure 9: Comparison of hydrologic regimes associated with 10 ha of existing forest and proposed industrial development

Figure 9 illustrates several distinct changes in the hydrologic response of an area follow industrialisation, namely:

- increased frequency of runoff events;
- increased flow duration;
- increased peak flows; and
- an increased net volume of runoff.

Compared to the 20% of rainfall becoming runoff on the existing site, up to 90% will become runoff following development of allotments. The magnitude and frequency of these changes in hydrology are also seen when the simulation results are ranked in order of driest to wettest days as in Figure 10.

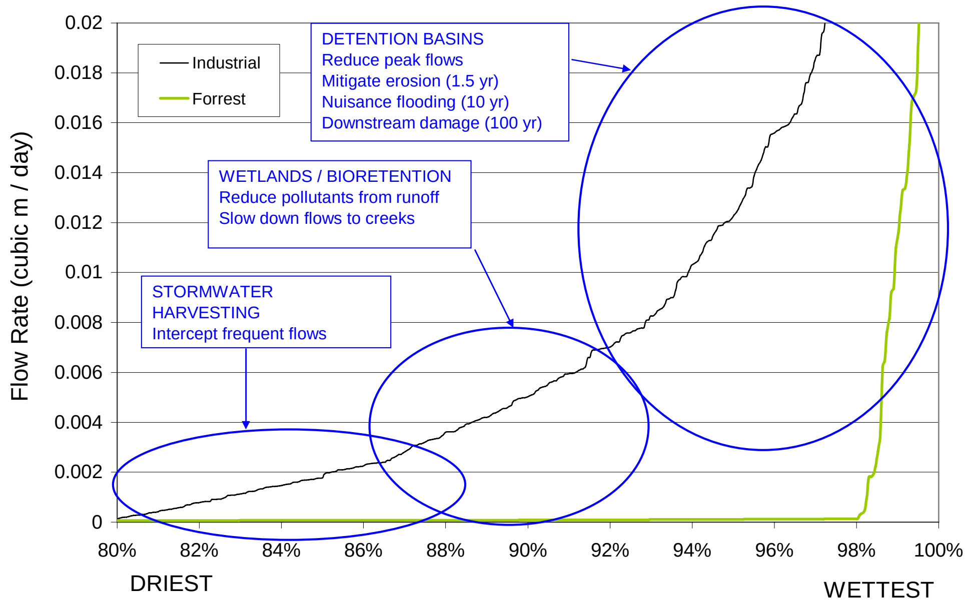

Figure 10: Comparison of hydrologic regimes associated with existing forest and industrial development and the magnitude of events targeted by management strategies.

Figure 10 shows that frequency of runoff from a nominal area increases by an order of magnitude after development. These associated impacts of this change and proposed management strategies are summarised in Table 1.

Table 1: Hydrologic effects associated with industrial development, corresponding ecological impacts and management strategies t

Hydrologic Impacts of Increased Runoff Volumes	**Ecological Impacts**	**Management strategy**
Increased peak low flows (1.5 yr ARI)	Accelerated stream erosion, increased sediment loads to receiving waters, habitat loss	Attenuation with on site detention basins
Increased peak nuisance flows (5-10 yr ARI)	Increased burdens to stormwater infrastructure and disruptions to site activities	Attenuation with on site detention basins
Increased peak flood flows (100 yr ARI)	Increased flood impacts downstream	Attenuation with on site detention basin
Increased frequency of stream flow and erosion events	Accelerated stream erosion, loss of ephemeral ecology and habitat loss	Stormwater harvesting and reuse
Prolonged duration of stream flow events	Accelerated stream erosion, loss of ephemeral ecology and habitat loss	Control of site discharge rates
Increased stream flow velocities	Accelerated stream erosion, incision of channels, changes to ephemeral floodplain	Drainage swales and in stream works

4.4 POTENTIAL WATER QUALITY IMPACTS

A range of potential stormwater pollutants are associated with industrial site activities including toxicants, nutrients, suspended solids, litter and oxygen demanding substances. These substances must be controlled to avoid significant loads entering the stormwater system and downstream waterways. A list of typical pollutants, their ecological impacts and common management strategies are summarised in Table 2.

Table 2: Potential stormwater pollutants associated with industrial developments, corresponding ecological impacts and management strategies .

Potential Stormwater Pollutants	Ecological Impacts	Management strategy
Oils, heavy metals, hydrocarbons and toxicants associated with incidental spills	Ecological impacts and downstream water quality impacts	Structural isolation of activities and Environmental Management Plans
Increased nutrient loads (nitrogen and phosphorous)	Eutrofication of downstream waterways, promotion of algal growth, weed growth and changes to soil chemistry.	Bioretention and wetland treatment
Increased loads of sediment	Smothering of benthic organisms	Sedimentation zones and swales

4.5 POTENTIAL GROUNDWATER IMPACTS

A range of potential stormwater pollutants are associated with industrial site activities including toxicants, nutrients, suspended solids, litter and oxygen demanding substances. These substances must be controlled to avoid significant loads entering the stormwater system and

4.6 MODELLING RUNOFF AND POLLUTANT LOADS FROM HEZ

Stormwater modelling was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), a model developed by the CRC for Catchment Hydrology, for determining the impact of water quality treatment measures. The model used four years (1981 – 1985) of 6 minute rainfall data from the Pokolbin rainfall gauge which has a mean annual rainfall 741 mm/yr. The Pokolbin gauge compares with mean annual rainfall measured at the Cessnock Post Office and was selected to give a better estimation of stormwater treatment performance according to current best practice using 6 minute pluviograph rainfall data.

Mean annual stormwater runoff volumes and typical urban pollutant loads from the existing forest and proposed HEZ development are presented in Table 3. The latter are potential pollutant loads from a typical industrial development comprising approximately 80% roof and hardstand areas without any stormwater treatment, and the remaining 20% of lots reinstated with forest as proposed within the Stage 1 Precinct.

Table 3: Stormwater runoff volumes and potential stormwater pollutants associated with HEZ and pre-developed forest.

Runoff and Pollutant Loads	Pre-developed forest	Unmitigated HEZ*
Flow (ML/yr)	1122	4755
Total Suspended Solids (kg/yr)	141,810	1,489,962
Total Phosphorus (kg/yr)	84	1673
Total Nitrogen (kg/yr)	939	13,759
Gross Pollutants (kg/yr)	10	136,418

The effect of change in land use is significant in terms of runoff and pollutant loads generated.

5

5 OBJECTIVES AND MANAGEMENT OF POTENTIAL WATER CYCLE IMPACTS

The water cycle management objectives of the HEZ aim to reduce potable water use and wastewater generation, avoid stormwater pollution, mitigate flood flows and prevent stream erosion. The management objectives and strategies represent best practice environmental principles for development within New South Wales.

5.1 MANAGEMENT STRATEGY OBJECTIVES

While the existing HEZ site currently supports a good stand of forest and fauna habitat, a number of waterways are showing erosion impacts from previous land use and clearing. These erosion impacts require remediation to improve stream structure and prevent ongoing damage.

The proposed HEZ development will increase runoff volumes that could potentially worsen the existing erosion across the site and worsen downstream flooding impacts within Weston. Stormwater pollutants associated with industrial practices could degrade habitat values across the site as well as impact downstream water quality.

A combination of integrated management objectives and best practice environmental management principles are proposed to avert the degradation of the local aquatic ecosystems, as well as preserve drinking water reserves and reduce wastewater flows to receiving waters.

Water cycle, surface water and soil conservation management objectives recommended for the HEZ site are outlined in Table 4. The following discussion explains the purpose and implications of each objective.

Table 4: WSUD objectives for the HEZ development

Management Principal	Performance Objective
Management of existing stream stability and erosion issues	Mitigation of existing erosion processes through controls and rock chute construction
Structural isolation of stormwater	Exclusion of industrial pollutants from stormwater and creeks by: • Covering industrial activities where possible. • Bunding liquid chemical storage areas. • Draining uncovered areas of industrial activities to evaporation ponds or sumps • Draining indoor areas to sewer.
Site management	Minimise the risk of soil and stormwater contamination through the establishment of Environmental Management Plans for each industrial lot.
Potable water conservation and wastewater generation	Reduction in potable water demand through water efficiency fittings. Reduction in wastewater generation through reduced water use. Potable water substitution through minimum stormwater reuse rates of 15 kL/day/Ha of development for each lot
Stormwater Quality	85% retention of total suspended solids (TSS) loads from developed areas. 65% retention of total phosphorus (TP) loads from developed areas. 45% retention of total nitrogen (TN) loads from developed areas Retention of litter greater than 50 mm for flows up to the 3-month event No hydrocarbons or oils to be visible in flows leaving sites up to the 3 month peak flow
Flood management	No increase in 100 yr ARI peak flows or flood levels downstream of HEZ.
Waterway erosion and stability management	No increase in 1.5 year Average Recurrence Interval (ARI) peak flows from developed lots Minimum stormwater reuse rates of 15 kL/day/Ha of development for each lot A minimum of 55% reduction in Mean Annual Runoff Volume (MARV) from impervious surfaces for each lot
Groundwater recharge	Establishment of groundwater recharge areas for treated stormwater where ever soils are conducive to infiltration.

Notes: * Excludes industrial process and food processing demands that require potable water quality

5.2 INSTREAM RIPARIAN WORKS

In order to prevent further degradation of streams, a stream rehabilitation scheme is to be undertaken to improve the stability of waterways throughout the HEZ.

Existing erosion heads are to be stabilised by a program of constructed rock chutes to reduce the hydraulic gradient of streams. Rock chutes provide a reinforced bed that can tolerate the high shear stress associated with high velocity flows occurring in a short and steep section of stream bed. The design and location of the rock chutes will depend on the specific conditions at the site. An example of a series of rock chutes under medium flow conditions is shown in Figure 11.

Figure 11 : Rock chutes under medium flow conditions at Lilac Street stream rehabilitation scheme

Performance Targets and Compliance

In stream riparian works are to achieve reductions in erosion rates of waterways, stabilisation of creek channels and reduction in deposition of sediments in aquatic habitats.

5.3 STRUCTURAL ISOLATION OF STORMWATER

Industrial site design is fundamental to minimising the generation and management of stormwater pollutants by providing multiple barriers to ensure potential pollutants do not enter the stormwater system and escape to waterways.

This objective recognises that certain industrial processes are more benign than others and exempts structural isolation from industrial activities involving solid inert materials.

Industrial activities requiring structural isolation to protect stormwater include the following:

- Any process of manufacture.
- Dismantling or breaking up of any article.
- Treating waste materials.