Basic raw materials extraction

Scope

This note applies to extractive industries\(^1\) that remove basic raw materials (BRM) from the ground. BRM includes sand (including silica sand), clay, hard rock, limestone (including metallurgic limestone), gravel, gypsum and other construction and road building materials\(^2\).

Extractive industries generally consist of an active point of extraction (e.g. a pit) that may be mobile, following the resource through the landscape (sometimes in-stream), and a processing site (i.e. for stockpiling, lay down areas, washing, crushing and screening). This note covers both.

Often, BRM extraction requires incidental developments such as roads, offices, workshops and staff amenities. This note also applies to these facilities, but more detailed guidance for those land uses is available in other Department of Water and Environmental Regulation (DWER) water quality protection notes (WQPNs; visit our website www.dwer.wa.gov.au).

This note provides recommendations to BRM operators on how to limit the impacts of their operations to the environment and water resources. It applies to new proposals and the expansion of existing operations. DWER encourages the operators of existing BRM operations to adopt the recommendations in this note. It replaces:

- Statewide policy no. 1: Policy and guidelines for construction and silica sand mining in public drinking water source areas (Water and Rivers Commission 1999)
- WQPN no. 15: Extractive industries near sensitive water resources (Department of Water 2003)

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\(^1\) Industry – extractive is defined in the model scheme template as ‘premises, other than premises used for mining operations, that are used for the extraction of basic raw materials including by means of ripping, blasting or dredging and may include facilities for any of the following purposes: (a) the processing of raw materials including crushing, screening, washing, blending or grading; (b) activities associated with the extraction of basic raw materials including wastewater treatment, storage, rehabilitation, loading, transportation, maintenance and administration’ (Government of Western Australia 2015). For industry – mining, please refer to our Water quality protection guidelines for mining and mineral processing, available www.dwer.wa.gov.au.

\(^2\) As defined in Draft State planning policy (SPP) 2.4: Basic raw materials (Western Australian Planning Commission 2018).
• South West Region guideline: Water resource considerations for extractive industries (Department of Water 2014).

It supports the water resource protection aspects in the Guideline for mining proposals in Western Australia (Department of Mines and Petroleum 2016).

Standard information to be read in conjunction with this note can be found in WQPN no. 3: Using water quality protection notes (Department of Water 2016c).

Water quality contamination risks

BRM extraction can pose the following risks to water resources:

• dramatic changes in hydrological regimes such as groundwater level changes, flooding and waterway channel migration, sometimes well beyond the extraction site or many years later
• exposure of the groundwater table leading to evaporation, and providing a pathway for contamination to enter the aquifer
• erosion, with the eroded soil running off into surface water sources, reducing water clarity, transporting other contaminants, clogging infrastructure such as culverts, pipes and drains, degrading waterways and wetlands and their ecological values and acting as a ‘mask’ to drinking water treatment processes
• hydrocarbons and chemicals from fuel, oil and chemical leaks and spills, affecting surface water and groundwater quality
• pathogens from septic tanks and staff amenities, posing a risk to water quality and public health (for more information about pathogens, see our brochure Risks from pathogenic micro-organisms in PDWSAs, Department of Water no date).

For general information about protecting water quality, see WQPN no. 8: Further reading (Department of Water 2016d).

Approvals required

On crown and reserved land, the Department of Mines, Industry Regulation and Safety (DMIRS) is responsible for issuing approvals for BRM extraction. On privately owned land, responsibility is delegated to local governments under the Planning and Development Act 2005. Refer to the BRM applicants manual (Western Australian Planning Commission 2009) for more information.

An administrative agreement between DMIRS and DWER was established to streamline interaction between the departments regarding water resource management in mining (Department of Water & Department of Mines and Petroleum 2016). It sets out processes and protocols, and includes schedules of standard endorsements for regulating mining activities under the Mining Act 1978. When water resource management areas are affected, DMIRS applies these standard endorsements upon the granting of mining tenements.
The applicant is responsible for gaining all relevant DWER approvals. The type and number of approvals required is mainly dependent on the work to be undertaken and the location of the project and may include:

- BRM operations that are using a mechanical plant to screen, wash, crush, grind, mill, size or separate over 5000 tonnes of extracted material per year require a works approval and licence³ under Part V the *Environmental Protection Act 1986*.

- Mechanical plant operations (regardless of the amount of extracted material processed) must comply with the Environmental Protection (Noise) Regulations 1997 and Environmental Protection (Unauthorised Discharge) Regulations 2004.

- A permit may be required for clearing of native vegetation under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

- BRM operations in proclaimed *Rights in Water and Irrigation Act 1914* areas may need a licence to construct a bore and take groundwater or surface water (including dewatering), or a permit to divert surface water, or to interfere with beds and banks of a watercourse. All artesian bores and the water taken from them also require a licence.

- Please seek advice from DWER if BRM extraction is proposed in a waterway management area proclaimed under the *Waterways Conservation Act 1976* (Department of Water & Department of Mines and Petroleum 2016).

- A licence is required to clear land for BRM operations within a clearing controlled catchment (Denmark, Harris, Kent, Mundaring, Warren and Wellington) under the *Country Areas Water Supply Act 1947*. Please contact cawsa@dwer.wa.gov.au.

- All proposals, regardless of the types of approvals required, may be subject to assessment by the Environmental Protection Authority if there is a significant impact on the environment.

- DWER also recommends that any proposed BRM extraction near sensitive water resources⁴ be referred to us for advice by the decision-making authority.

Mapping of the above areas is available at [www.data.wa.gov.au](http://www.data.wa.gov.au). To find out what information we may require to assess proposals, please read WQPN no. 18: *Information the department requires to assess a proposed development or activity*. For more information about these approvals and assessments, visit [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au) or contact us.

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³ Industrial premises with potential to cause emissions and discharges to air, land or water are known as ‘prescribed premises’ and trigger regulation under the *Environmental Protection Act 1986*. Prescribed premises categories are outlined in Schedule 1 of the Environmental Protection Regulations 1987.

⁴ For a definition of ‘sensitive water resources’, please refer to WQPN no. 4: *Sensitive water resources*
Recommendations

Location

Public drinking water source areas

Public drinking water source areas (PDWSAs) are surface water catchments and groundwater areas that provide drinking water to cities, towns and communities throughout the state. PDWSAs are proclaimed under the Metropolitan Water Supply, Sewerage, and Drainage Act 1909 or the Country Areas Water Supply Act 1947. Their locations can be found at [www.data.wa.gov.au](http://www.data.wa.gov.au). For more information, see our Strategic policy: Protecting public drinking water sources in WA (Department of Water 2016a) and our WQPN no. 25: Land use compatibility tables for public drinking water source areas (Department of Water 2016b).

The following recommendations apply to BRM extraction within PDWSAs:

- BRM extraction is ‘compatible with conditions’ in priority 1 (P1), priority 2 (P2) and priority 3 (P3) areas (Department of Water 2016b). Conditions are outlined in this note.

- To find out the compatibilities of other land uses and activities that may be associated with the BRM extraction, refer to our WQPN no. 25: Land use compatibility tables for public drinking water source areas (Department of Water 2016b).

- In P1 areas, a minimum of 3 m undisturbed profile is required, to the highest groundwater level. In P2 and P3 areas, it is a minimum of 2 m.

- Avoid wellhead protection zones (WHPZs) and reservoir protection zones (RPZs) (unless DWER approves in writing). By-laws may apply in these areas. Additionally, Schedule 2: Public drinking water source areas of the administrative agreement (Department of Water & Department of Mines and Petroleum 2016) may prevent BRM extraction in these areas.

- BRM extraction should be staged so that operations commence at the furthest distance away from protection zones, enabling best management practices to be well established prior to mining closer to these water supply abstraction points.

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5 See Appendix A for further information about how separation distances were determined.

6 The highest level of the saturated zone in the soil. Where measurement is required, this is represented by the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero (Watts & Hurt 1991). Highest groundwater level should take into account the range of seasonal groundwater conditions in the context of long-term variability and possible groundwater rise following extraction of BRM. The scale of investigation and analysis will depend on the presence of local water resources, the availability of existing data, the proposed BRM operation and any associated risks. DWER’s Water resource considerations when controlling groundwater levels in urban development (Department of Water 2013) provides details of the considerations when assessing the groundwater regime and groundwater levels; the principles outlined in this publication are relevant to groundwater investigations for BRM operation. Groundwater information is available via Water information reporting on our website at [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au). Seek advice from DWER about the level of investigations required.
• Operators need to liaise with the water service provider to ensure drinking water supply infrastructure is protected.

• Dry methods of extraction should be used.

• Fuel and chemical storage should be in accordance with WQPN no. 65 *Toxic and hazardous substances* and WQPN no. 56: *Tanks for fuel and chemical storage near sensitive water resources*. Additionally, schedules 2.1 and 2.2 of the administrative agreement (Department of Water & Department of Mines and Petroleum 2016) state that the handling, storage, transport and use of toxic and hazardous substances (including human wastes) within PDWSAs is prohibited (unless approved in writing by DWER).

• In the absence of a DWER-approved water management plan or fuel management plan, any refuelling, mechanical servicing and wash down should be conducted outside of P1 and P2 areas.

• Employees should be trained and reminded via signs of the potential risks to drinking water quality in a PDWSA. Refer to our brochure *Living and working in PDWSAs* (Department of Water 2011).

*Gnangara public drinking water source area*

The Gnangara PDWSA is constituted as the Gnangara Underground Water Pollution Control Area under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* and provides a significant source of drinking water for Perth. Its location can be found at [www.data.wa.gov.au](http://www.data.wa.gov.au).

The majority of BRM in the Gnangara PDWSA lies under current or past pine plantations. The department recognises the strategic importance of BRM extraction and the importance of protecting PDWSAs to continue the availability of reliable, good quality, low cost drinking water to the public, now and in the future.

DWER’s recent modelling using the Perth Region Aquifer Modelling System (PRAMS) shows that groundwater levels in the Gnangara PDWSA are changing. This is due to climate change, planned increases in urbanisation, proposed reduction to groundwater abstraction and the management of pine plantations. Therefore, the regional model is needed to predict the highest groundwater level to determine vertical separation distances for BRM extraction.

The department conducted investigations during 2017 to address this, which resulted in the following special condition:

• The highest groundwater level for the Gnangara PDWSA, from which to determine separation distances for BRM extraction, is the *highest groundwater levels from the year 2000*.

This level approximates the PRAMS analysis, reflects the last time that water levels at the majority of Gnangara groundwater-dependent ecosystems met criteria set in *Ministerial statement no. 819* (Office of the Appeals Convenor 2009) and is definable using existing, readily available data (see *Water information reporting* at [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au)).
Clearing control catchments (Country Areas Water Supply Act 1947)

- BRM activities within clearing control catchments need to be assessed for potential salinity impacts. Please contact cawsa@dwer.wa.gov.au.

Near waterways

- BRM extraction should be above the 1 in 100 (1 per cent) annual exceedance probability flood level. To find out flood information, visit www.data.wa.gov.au.
- Areas subject to seasonal inundation or waterlogging should be avoided.
- Adequate buffers between waterways and their foreshore areas need to be maintained. Refer to Operational policy 4.3: Identifying and establishing waterways foreshore areas and Determining foreshore reserves (Department of Water 2012).
- For any land- or water-based developments or activities near the Swan, Canning, Helena or Southern rivers, please contact the Department of Biodiversity, Conservation and Attractions (DBCA) for special requirements (www.dbca.wa.gov.au).

BRM extraction within waterways (in-stream mining)

In-stream mining occurs when BRM is extracted from river beds or from pits in floodplains. This occurs mostly in the north-west of WA in seasonal and ephemeral waterways (that is, waterways that do not flow all year round). Alluvial deposits are easily extracted from the surface, require little processing and are periodically replenished with new material from upstream during periods of high water flow.

Waterways are complex and dynamic systems that vary in their sensitivity and response to disturbances such as in-stream mining. In-stream mining can cause erosion of beds and banks, widening of the river channel which poses a risk to infrastructure (such as bridge piers and pipelines), sedimentation, a reduction in surface and groundwater quality and damage to aquatic and riparian habitats, flora and fauna.

- Appendix B provides specific information for in-stream mining proposals which should be applied in addition to the other recommendations in this note.
- If you are proposing in-stream mining that is also within a PDWSA, please contact us for advice, as site-specific management measures may need to be applied.

Wetlands

To find out the locations of wetlands, and any separation distances or special measures that may be required, contact DBCA (www.dbca.wa.gov.au).

Groundwater

- Acid sulfate soil risks need to be assessed and mitigated, visit www.dwer.wa.gov.au or contact us for more information.

Where dewatering is not required:
• Maintain an adequate vertical separation distance between the base of extraction and the highest groundwater level\(^7\) to protect water quality and ensure evaporation doesn’t occur, both during and after extraction. Both of these separation distances should be determined during planning approvals processes, before activities commence. The following points need to be considered when determining these distances:
  - During extraction, this distance depends on site-specific factors, contact DWER for more information.
  - The post-mining separation distance needs to be appropriate for the future land use (i.e. according to the relevant local planning scheme). If the land use will be urban, please refer to our *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013) for more information.
  - DWER encourages development approval conditions that stipulate maximum pit floor depths.

• If any groundwater interception occurs during extraction (that is not in accordance with the extractive industry licence conditions), work should cease and an advice notice be provided to the relevant approval authority within 24 hours (see *Approvals required* section), followed by agreed remedial action.

If dewatering is required:

• If the proposal is within a proclaimed groundwater area under the *Rights in Water and Irrigation Act 1914*, a licence to dewater may be required. Please contact DWER to determine what additional information is required to be submitted for approvals (see *Approvals required* section), such as a hydrogeological report. Refer to WQPN no. 13: *Dewatering of soils at construction sites* for more information about requirements for dewatering.

*Landscape*

• Ideally, the land selected should be gently sloping (between 1 in 20 and 1 in 50) so runoff and wastes can be more easily managed, but erosion is avoided.

• Rocky and steep slopes, and land prone to erosion should be avoided.

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\(^7\) The highest level of the saturated zone in the soil. Where measurement is required, this is represented by the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero (Watts & Hurt 1991). Highest groundwater level should take into account the range of seasonal groundwater conditions in the context of long-term variability and possible groundwater rise following extraction of BRM. The scale of investigation and analysis will depend on the presence of local water resources, the availability of existing data, the proposed BRM operation and any associated risks. DWER’s *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013) provides details of the considerations when assessing the groundwater regime and groundwater levels, the principles outlined in this publication are relevant to groundwater investigations for BRM operation. Groundwater information is available via *Water information reporting* on our website at www.dwer.wa.gov.au. Seek advice from DWER about the level of investigations required.
• Post-mining landscapes should be identified and agreed upon through consultation prior to the approval of new projects (see *Closure, rehabilitation and subsequent land uses*).

*Other land uses*

• Separation distances between BRM extraction and sensitive land uses – such as urban areas – may apply, as stated in Guidance statement no. 3: *Separation distances between industrial and sensitive land uses* (Environmental Protection Authority 2005).

• Infrastructure should be avoided, and adequate separation distances should be maintained to ensure its operation is not compromised. Please consult with the relevant operator/owner of the infrastructure.

*Construction*

• Use existing roads and tracks to access the site where possible. New access ways onto major roads should not be created.

• Access routes to the excavation area should be restricted to the minimum necessary (i.e. the least possible creek crossings) and selected for the least impact (i.e. areas with minimum vegetation).

• Creek crossings should be constructed in accordance with *Building creek crossings* (Department of Water 2010). If located within a proclaimed surface water area under the *Rights in Water and Irrigation Act 1914*, a permit to interfere with the beds and banks may be required (contact us).

• Roads should be constructed in accordance with WQPN no. 44: *Roads near sensitive water resources*.

*Operation and management*

• Extraction should be staged so that at any one time the permissible active area of extraction is in accordance with the relevant approvals (i.e. local government’s extractive industry licence conditions or DMIRS approval conditions).

*Solid waste*

• It is an offence under the Environmental Protection (Unauthorised Discharges) Regulations 2004 to cause or allow scheduled items to be discharged to the environment. Scheduled items include (but are not limited to) acids, hydrocarbons and sediment.

• Any wastes that cannot be reused or recycled in the operation should be stored appropriately and disposed of off-site at an approved facility.

*Water supply*

• If your operation is within a proclaimed surface water or groundwater area under the *Rights in Water and Irrigation Act 1914*, you may need a licence to construct a bore, and abstract groundwater or surface water. All artesian bores and the water
taken from them are licensed under the act. Please visit [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au) or contact us for more information.

- Uncontaminated stormwater should be reused in the operations where possible.
- If the operation is not connected to a scheme supply, and a potable water source is required, see our WQPN no. 9: *Community drinking water sources – protection and management* for more information.
- Low volume, high pressure water hoses should be used for wash down to minimise the amount of water used, which will reduce cost and the volume of wastewater required to be managed.

**Wastewater**

- Facilities should be connected to deep sewerage if available. If not, onsite wastewater treatment systems should be installed in accordance with the *Government sewerage policy* (Western Australian Planning Commission draft 2016, or as updated).
- Small-scale facilities may not require permanent toilet facilities, so for these sites, portable toilets should be provided according to *Health Act 1911* requirements. Contact your local government for advice.

**Stormwater**

- Stormwater from ‘clean’ areas such as roofs, clean paved areas and areas outside of the work site should be directed away from operational areas.
- Stormwater originating from outside or adjacent to the works area should be diverted around the works area.
- Stormwater that may be contaminated should be treated and reused in the operations if appropriate.
- Stormwater flowing from disturbed areas, including areas for stockpiles, should be managed to prevent turbidity, such as via settling pits. The pits should be designed to handle up to a 2 hour, 1 in 10 (10 per cent) annual exceedance probability event.
- The following coefficients of runoff are appropriate to use for BRM excavation pits with a slope of 5 per cent or less, during the 2 hour, 1 in 10 (10 per cent) annual exceedance probability event and for the pit floor only (they should not be used for any other land uses). Values were derived using the ranges of recommended losses from *Australian Rainfall and Runoff* (Ball et al. 2019).

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient of runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>0.1</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.5</td>
</tr>
<tr>
<td>Gravel</td>
<td>0.8</td>
</tr>
<tr>
<td>Rock</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Overflow systems should be engineered to manage stormwater runoff resulting from greater than 2 hour, 1 in 10 (10 per cent) annual exceedance probability events, and up to the critical 1 in 100 (1 per cent) annual exceedance probability event. The overflow system and pathway should be designed to mitigate erosion and flood risks.

See our *Stormwater management manual for Western Australia* (Department of Water 2004–08) for more advice.

**Dust**

For prescribed premises under the *Environmental Protection Act 1986*, dust from processing and stockpiling activities may be considered to be a ‘specified emission’ and be subject to controls imposed via licence conditions. Dust from BRM extraction, including blasting and free digging, is not considered to be a component of the prescribed activity, and is subject to the general provisions of the act. Penalties apply for causing pollution or environmental harm.

Licences under the *Rights in Water and Irrigation Act 1914* for managing dust will be issued on a temporary basis with a reduced tenure. They will include conditions that they are not transferable to other users and will not be renewed past the life of the mine. Applicants will need to demonstrate how they will implement best practice to minimise the volume of water used. Please visit [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au) or contact us for more information.

Please refer to *A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities* (Department of Environment and Conservation 2011) for further information about managing dust.

**Toxic and hazardous substances**

Storage and use of any chemicals, fuels, pesticides and fertilisers should be in accordance with WQPN no. 65: *Toxic and hazardous substances* and WQPN 56: *Tanks for fuel and chemical storage near sensitive water resources*.

Herbicides used in PDWSAs should be limited to those specified in the Department of Health’s PSC 88: *Use of herbicides in water catchment areas*.

Contact the Department of Health for advice on the use of pesticides where they may contact people, food or water supplies.

Refuelling should occur within bunded compounds designed to allow effective recovery of spills. The bunded area must be capable of holding a 1 in 20 (5 per cent) annual exceedance probability, 72 hour storm event and 110 per cent of tank contents. Bunding should be high enough to contain wave action and jetting from leaks, but the size minimised to reduce the footprint of the containment area.

Dangerous goods should be stored and handled in accordance with the Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007. Explosives should be stored and handled in accordance with the Dangerous Goods Safety (Explosives) Regulations 2007. Contact DMIRS for more information ([www.dmirs.wa.gov.au](http://www.dmirs.wa.gov.au)).
Vehicles

- All machinery and vehicles should be regularly serviced and maintained, clean and free of oil, fuel, hydraulic or any other fluid leaks before entering the excavation area.
- Wash down of vehicles and any mechanical equipment should be undertaken as outlined in WQPN no. 68: *Mechanical equipment wash down*.
- All contaminated wash-down water should be directed to the wastewater treatment system.
- Any vehicle or machinery servicing and repairs should be in accordance with WQPN no. 28: *Mechanical servicing and workshops*.

Accidents and emergency response

- Any spills should be immediately cleaned up, with the solids disposed of appropriately in sealed containers for disposal offsite, and the residue should drain to a sealed collection sump, not into the environment.
- Any chemical spill or contaminated water that escapes containment should immediately be reported to the department’s Pollution Watch Hotline, phone 1300 784 782. If the spill is within a PDWSA, the Water Corporation should also be advised immediately, phone 13 13 75.
- A contingency plan should be available to address emergency situations such as accidents, fires, chemical spills and vandalism, which could impact water resources. See WQPN no. 10: *Contaminant spills – emergency response* for more information.

Monitoring

- Undertake a monitoring program under advice from the relevant approval authorities to check for impacts and changes. Consider using baseline monitoring, photo monitoring, aerial imagery, topographic surveys and soil, surface water and groundwater monitoring.
- Refer to WQPN no. 30: *Groundwater monitoring bores* for more information.

Closure, rehabilitation and subsequent land uses

- Consider the post-BRM extraction land use before starting extraction. This will help determine what the finished landscape needs to look like, how much BRM can be extracted and what the final separation to groundwater needs to be.
- The landscape should preferably be restored to conditions that are similar to the surrounding environment, including physical and biological processes. As a guide, consider whether the final landform is safe, stable, non-polluting and self-sustaining. Ongoing earthworks should not be needed to maintain the site.
- Ensure that an appropriate vertical separation distance to groundwater is achieved, considering the protection of groundwater and consistency with future land uses that are appropriate within the relevant local planning scheme.
• DWER does not support the creation of new water bodies by leaving open pits and voids. If an open water body is proposed for future recreation or conservation purposes, the proponent will need to demonstrate that issues such as water resource management, water quality protection and mosquitoes/midges can be successfully managed in the long-term. See DWER’s *Interim position statement: Constructed lakes* for more information (Department of Water 2007).

• Prepare a mine closure plan that:
  - considers the timing of the project; i.e. a staged closure plan may be required, with rehabilitation occurring as areas are closed off rather than waiting for the entire operation to cease
  - considers zoning and future use of the land and appropriate finished ground levels as pre-determined in a mining plan
  - specifies details of the final landform
  - specifies finished depth to groundwater levels, appropriate for the future land use
  - considers recontouring, stability and erosion risk
  - specifies appropriate material for backfilling if required
  - discusses proper removal of infrastructure (such as ramps)
  - addresses public and animal safety
  - outlines revegetation plans (if appropriate)
  - ensures any natural elements are replaced where required (i.e. large woody debris in streams)
  - refers to *Guidelines for preparing mine closure plans* (Department of Mines and Petroleum & Environmental Protection Authority 2015).

• If your site is within a PDWSA, please also refer to WQPN 84: *Rehabilitation of disturbed land in public drinking water source areas.*
Appendix A: Statewide policy no. 1

The following is an extract from Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in public drinking water source areas* (Water and Rivers Commission 1999), which outlines the important history and scientific information behind the 3 m (for P1 areas) and 2 m (for P2 and P3 areas) separation distances recommended for PDWSAs. Note that the functions of the Water and Rivers Commission have since been replaced by the Department of Water and Environmental Regulation.

Environmental impacts arising from sand mining activities include impacts on local and regional groundwater flow regime and the possible risk of groundwater pollution. An adequate clearance between the finished surface level and the highest known groundwater levels is of critical importance in ensuring impacts on water resources are minimised.

In determining an appropriate clearance the following issues were considered:

- sufficient clearance to allow accidental fuel spills to be contained in the unsaturated zone for a reasonable period of time
- sufficient clearance to ensure evaporation losses during mining are minimised
- sufficient clearance to ensure evapotranspiration losses from the rehabilitated minesite do not unacceptably reduce aquifer recharge.

**Sufficient clearance to allow fuel spills to be contained in the unsaturated zone**

Fuel spills and leaks from onsite storage facilities pose a threat of groundwater contamination. The most important element in the reduction of any groundwater hydrocarbon contamination is the extent to which the unsaturated zone above the watertable can contain the volume of fuel spilled.

In the event of a fuel spill, the unsaturated zone can minimise the possible lateral spread of the hydrocarbon plume, provide the opportunity for remediation and lessen the risk of contaminant interaction with the groundwater.

The vulnerability of water resources to contamination from fuel leaks depends on the retention capacity of the soils, depth to the watertable, seasonal watertable variations and quantity of fuel spilt.

Previously, a minimum 2 m clearance between the lowest mined profile and the highest known watertable was required. The Commission has reviewed this requirement and commissioned the Centre for Groundwater Studies (CGS) to conduct a study (Johnson, 1997). This study analysed the extent of diesel infiltration for likely fuel spill scenarios and also tested whether the depth of 2 m of unsaturated zone is sufficient to protect groundwater supplies from hydrocarbon contamination.
The simulated diesel spill scenarios modelled a range of situations, from large and extensive spills to smaller instantaneous releases over a longer period of time. The study assumed that the unsaturated zone consists of Bassendean Sands, which are typical of those being mined in underground water pollution control areas near Perth.

The study demonstrated that for slow leaks (5000 L, 400 L and 200 L of fuel leaking over 12 hours), the maximum depth of hydrocarbon infiltration would be contained in the range 0.64 m to 1.28 m. The time taken to reach these depths would range from 2.5 days to 50 days.

Hydrocarbon infiltration is sensitive to changes in soil characteristics, increasing in porous sandy soils.

For rapid spills (400 L of fuel spilled in 1 minute), the maximum depth of hydrocarbon infiltration would be contained in the 1.03 to 2.05 m zone. The time taken to reach these depths would range from 1.6 days to 12 days.

Considering the results of the CGS’s study, the Commission considers that the 2 m buffer zone of undisturbed sand profile is appropriate. This buffer minimises the risk of contamination of groundwater from hydrocarbons and allows time for remediation to take place.

**Sufficient clearance to ensure evaporation losses during mining are acceptable**

Direct evaporation of groundwater can take place when the watertable is close to the surface, usually within 0.5 to 2 m (Bouwer, 1996). Evaporation losses were found to be inversely proportional to the depth of the watertable. The relationship between the evaporation rate and watertable depth for sandy sediments, shows that with a watertable at a depth of 2 m the evaporation rate is approximately 1 mm/day (Bouwer, 1996).

Capillary rise also contributes to the process of evaporation. Empirical field data on sediments and other materials underlying the Swan Coastal Plain provides evidence that the watertable in these sediments can create a zone of capillary rise of 1.5 to 2 m (Davidson, 1995).

Existing data provide reasonable indication that a minimum thickness of 2 m of unsaturated zone is necessary to prohibit the loss of significant quantities of water through evaporation.

**Sufficient clearance to ensure evapotranspiration losses from the rehabilitated minesites do not unacceptably reduce aquifer recharge**

Transpiration is the loss of water vapour from vegetation. Where the depth to the groundwater table is small (typically less than 3 m) the vegetation will often establish roots which draw water directly from the watertable to meet their requirements. These plants are known as phreatophytes (Bouwer, 1996).

Bestow (1976) has demonstrated that in the Perth region, the amount of transpiration decreases as the depth to the watertable increases by approximately 400 mm per metre. For example where the depth to watertable
is 2 m, Bestow predicts transpiration losses will be about 700 mm; however, for a depth of 3 m the predicted transpiration loss will be around 300 mm and for 4 m transpiration losses will be negligible.

Farrington et al. (1988) found that within the range 4 to 12 m of the watertable depth over Gnangara Mound, the evapotranspiration rate is not correlated to depth of watertable.

Perth area receives around 870 mm of rain per year, not all of which infiltrates into the soil. In Priority 1 areas the depth to watertable should be maintained such that transpiration losses are small relative to rainfall. The minimum clearance in these areas is recommended to be 3 m (roughly equating to the minimum clearance for phreatophytic vegetation). This recognises that these sites will be revegetated following mining.
Appendix B: Recommendations for BRM extraction in waterways (in-stream mining)

Lower-risk locations
- BRM resources can sometimes be sourced from the floodplain area or abandoned stream channels such as on terraces and outer areas of floodplains. These can be easier to access and have lower environmental risk than mining within the waterway channel.
- Braided waterway systems are preferred over other types of river systems for BRM extraction, because they carry a lot of coarse sediment and are more dynamic, so they are less sensitive to disturbance.
- Larger waterways are preferred to smaller creeks and streams for BRM extraction, because large rivers have more sediment and the disturbance is proportionally smaller.

Floodplain mining
- Mining pits must be situated at least 30 m away from the top of the waterway banks. For larger waterways, a bigger buffer may be appropriate. Contact us for further advice, if required.
- Do not excavate floodplains below the thalweg in the adjacent channel. The thalweg is the lowest point of the bed along an entire reach of a waterway.

In-stream mining locations
- In-stream BRM excavation areas should:
  - not be within 1 km of a bridge, water supply facilities or pipelines
  - exclude in-stream island with established riparian vegetation
  - avoid eroding sections of waterways
  - identify permanent river pools and avoid impacts by providing an adequate buffer
  - minimise impacts to the waterway banks and riparian vegetation.
- Roads, processing sites, stockpiles and other infrastructure should be located away from the riparian zone, or at least 30 m away from the top of the waterway bank.
- Access ramps into the waterway should be less than 10 m wide, limited to the minimum number and have locations selected for the lowest risk to the channel banks and riparian vegetation. Where possible, select locations with minimal vegetation, gently sloping banks, located on straight sections of channels, and avoiding eroding areas.
Resource estimation and replenishment

- Extraction should only occur in aggrading areas, where the natural deposition and accumulation of sediments occurs, forming sand and gravel bars.
- Excavation should remove loose sediments only, not consolidated or calcreted sediments that form the channel bed or banks.
- An appropriate amount of sediment needs to remain in the system to maintain sediment transport processes, particularly for large, episodic floods.
- Test pits are recommended prior to mining to indicate the depth of loose aggrading material.
- Resource estimation should more accurately map the locations and depth of available resource taking into account the exclusion areas and buffers required (e.g. from bridges and pipelines, around permanent pools and in-stream vegetated islands, and from banks and low-flow channels).

Management measures

- Extraction should commence when dry season river flow declines and a sufficient portion of the channel bed is exposed. Extraction should cease before the wet season, before the risk of inundation of the mined area increases.
- Shallow extraction over a wider area of the river bed may be more sustainable and have lower environmental risk than extraction from a deeper pit.
- Extraction sites must be located a sufficient distance from the base of the dominant channel banks. The recommended buffer is 10 per cent of the dominant channel width or 3 m (whichever is greater), measured from the base (toe) of the bank.
- If the river is not completely dry, excavation can occur in elevated dry parts of the channel, but must not occur below the depth of the water level in the low flow channel; and buffers should protect the low-flow channel and the channel bank on either side of the excavation area.
- Do not excavate within 0.5 m of the current watertable. If the watertable is accidentally exposed, extraction should immediately cease in that location and the area should be backfilled with original material to at least 0.5 m above the watertable.
- Refuelling should occur outside of the waterway and buffer.
- Significant vegetation in the waterway (e.g. large mature trees) should be protected by a 2 m buffer from the drip line (outer edge) of the foliage or canopy to protect essential root systems.
- Avoid disturbing roughness elements (such as large woody debris) in the waterway where possible. Those that are disturbed should be retained for later replacement.
- Stockpiles within the channel should be removed before the start of the wet season.
• Deeper mining pits should be recontoured for stability (to prevent erosion) before the start of the wet season.

**Monitoring**

• Monitoring may be required to evaluate the upstream and downstream effects and any potential long-term channel changes as a result of in-stream mining.

• It may be necessary to monitor the sediment replenishment after major river flows to demonstrate the sustainability of the extraction rate.

• When extraction is undertaken near permanent pools, monitoring may be required to identify and minimise detrimental impacts.
References


——2003, Water quality protection note no. 15: *Extractive industries near sensitive water resources*, Government of Western Australia, Perth. (Replaced by this WQPN).


——2014, South West Region guideline: *Water resource considerations for extractive industries*, Government of Western Australia, Perth. (Replaced by this WQPN).


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