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# Prioritising risks for rehabilitation from a legacy of mining in Western Australia

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## Abstract

*Western Australia has a rich mining history stretching back to the mid-1800s. Thousands of abandoned mine features still exist across the state, including shafts, costeans, large pit voids and constructed landforms. Many of these abandoned mine features have been captured in the Abandoned Mines Inventory.*

*The Abandoned Mines Program (AMP) began in 2015 following the enactment of the Mining Rehabilitation Fund Act 2012 (MRF Act). The AMP develops and implements projects to rehabilitate abandoned mines in Western Australia using funds generated through the MRF. Initially work under the MRF was limited by available funds and only small projects were able to be undertaken to address known risks presented by historic mining operations. As the program has grown in line with available funds it has become apparent that the initial prioritisation framework was focused on significant risks associated with individual features and not specific to project development. Given there are approximately 190,000 abandoned mine features identified on the Abandoned Mines Inventory, a prioritisation methodology is required that enables selection of rehabilitation projects according to the risks presented to the community and the environment. The AMP has undertaken a full revision of the approach to prioritising abandoned mine projects to ensure future projects are appropriately selected by considering a range of criteria and that the prioritisation methodology is robust, repeatable and fully transparent to all AMP stakeholders.*

**Keywords:** *abandoned mines, risk assessment, prioritisation, risk management, rehabilitation, mining legacy*

## 1 Introduction

In the late 1990s an inventory of abandoned mines was collated by the Geological Survey of Western Australia (GSWA), capturing baseline data relating to historical mining-related features that have evolved over the long history of mining operations across the state (Ormsby et al. 2003). The data was consolidated into the Western Australian Abandoned Mine Sites dataset (WABMINES) within the Department of Energy, Mines, Industrial Regulation and Safety's (DEMIRS) Mines and Mineral Deposits (MINEDEX) database. While not a complete record of the abandoned sites in Western Australia, this dataset currently contains over 190,000 abandoned mine site features and additional features have subsequently been reported by the public. In the early 2000s, an abandoned mines risk assessment model (GHD 2005) was developed to assess the safety risk of abandoned mines for the purpose of prioritisation of high-risk abandoned mine features.

The Mining Rehabilitation Fund Act 2012 (Government of WA 2012) (MRF Act) introduced the MRF, a pooled fund levied annually from Mining Act tenement holders based on disturbance areas. Money from the principal fund can be used to rehabilitate abandoned mine sites where tenement holders who have contributed to the fund fail to meet their rehabilitation obligations. Investment income (interest) from the fund can be spent on administration of the MRF and the rehabilitation of historical or legacy mine features that existed prior to the introduction of the MRF Act or for which contributions to the MRF were not made.

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The Abandoned Mines Program (AMP) was established to deliver the management and/or rehabilitation of abandoned mine sites funded through the MRF.

The AMP was introduced following the enactment of the MRF and is guided by the WA Government's Abandoned Mines Policy 2016 (the Policy) (Department of Mines and Petroleum [DMP] 2016). The Policy requires that a risk-based approach focused on community safety and environmental impacts forms the basis for prioritising and subsequent management and/or rehabilitation of abandoned mine sites in WA.

A prioritisation framework (Mitchell et al. 2019) was developed under the AMP in accordance with the objectives and principles outlined in the Policy to enable an approach to be applied in determining priority sites. Having used the prioritisation framework for several years, the DEMIRS embarked on a project to review and update the prioritisation tool with the following objectives:

- maintaining consistency with the Abandoned Mines Policy (DMP 2016)
- adopting a risk-based approach focused on health, safety, and environmental and community impacts
- transparency with well-documented procedures for easy understanding
- repeatability and the ability to deliver consistent results
- the ability to incorporate the assessment of newly identified or recorded features
- allowing a feature's attributes to be edited and those edits incorporated into the prioritisation processes
- prioritising specific areas or locations to progress to a rehabilitation project stage where a specific area or location may include only one feature or may include a group of features.

This paper provides an overview of the updated methodology adopted through the Abandoned Mines Prioritisation Tool to prioritise high-risk abandoned mine features for management and/or rehabilitation under the AMP.

# 2 AMP

The rich history of mining across WA since the mid-1800s has left a legacy of thousands of abandoned mine features across the state. These include shafts, costeans, pit voids, mine tailings and constructed landforms (Department of Energy, Mines, Industrial Regulation and Safety's [DEMIRS] ca. 2021). In 1997 the GSWA commenced a program to capture, from a safety perspective, baseline data relating to historical mining-related features. While not a complete record of the abandoned sites in the state, the Abandoned Mines Inventory (the Inventory) currently contains over 190,000 abandoned mine features.

The AMP began in 2015 following the enactment of the MRF Act and release of the WA Government's Policy (DMP 2016). The MRF aims to ensure that the community of WA does not bear the financial burden for the rehabilitation of abandoned mining operations. The Policy (DMP 2016) provides the framework and policy principals for the assessment, prioritisation, management and rehabilitation of abandoned mine sites. A significant aspect of the AMP is the prioritisation of sites based on the community and the environmental risks they pose. The program also seeks to identify and protect the potential value associated with a site.

It is more than 10 years since the enactment of the MRF Act which provided the impetus to review the prioritisation process. An appraisal of the projects initiated against the prioritisation framework identified that the development of legacy projects, in particular Safer Shafts for Towns, had deviated from the direction of the original prioritisation framework as described by Mitchell et al. (2019). Addressing the mining legacy of the gold rush era, the Safer Shafts for Towns project focuses on reducing the safety risk of abandoned mine shafts located in proximity to towns. Project locations were selected based on the risk posed to a single child in any given location by the number of unrehabilitated shafts.

The project appraisal also found that while the prioritisation framework identified and prioritised single features which present significant risks, it is difficult to develop cost-effective projects around single significant-risk features when there are other features of the same category (such as shafts) which ultimately should be considered in the risk ranking.

The appraisal process identified that the risk and prioritisation framework required revising to ensure that the prioritisation of work under the AMP is transparent and repeatable.

The AMP strategy provided the direction to establish a leading practice approach to the prioritisation of risks associated with abandoned mines. The strategy also identified that it is essential the process is not only fit for purpose but also adaptive for future needs, and that it provides leading guidance in the execution of the program.

# 3 Prioritisation methodology development

A review and update of the prioritisation method for abandoned mines rehabilitation commenced in 2023 with the aim of creating a more robust, repeatable and transparent approach. This process took over six months and involved multiple workshops to develop a methodology that could be integrated into the current AMP process while also improving the overall reliability of the prioritisation process.

International Organization for Standardisation (ISO) 31000:2018 Risk Management — Guidelines (ISO 2018) is an international standard for managing risks faced by organisations. This standard is not specific to any industry or sector and therefore it can be used as a standard approach to risk management. In accordance with the AMP Policy principles, a risk-based approach focused on community safety and environmental impact should form the basis for abandoned mine site management and/or rehabilitation prioritisation (DMP 2016). Accordingly, ISO 31000 was used as the basis for designing the prioritisation methodology, which considers both consequence and likelihood to assess the risk.

The approach to the development of the prioritisation methodology involved the following key stages:

**Stage 1 literature review** — A desktop literature review of approaches used by other Australian agencies was completed to identify potential opportunities for alignment and/or optimisation which could be included within the updated prioritisation methodology. This included consideration of alignment with ISO 31000 risk assessment principles.

**Stage 2 priorities workshop** — Findings of the desktop review were compiled and discussed during a workshop with DEMIRS stakeholders. The workshop validated and refined the key drivers and priorities to be incorporated into the prioritisation methodology.

**Stage 3 prioritisation methodology** — Development and refinement of the prioritisation methodology was undertaken through a series of workshops and desktop analysis. This included definition of the nominated assessment criteria and risk-based methodology.

**Stage 4 prioritisation tool** — Development of the prioritisation tool using Feature Manipulation Engine (FME) Workbench software integrated with available datasets was conducted, providing a tool for the assessment of all features in the Inventory.

While the prioritisation methodology and tool were being developed, the approach was continuously refined and validated through workshop sessions. These refinement sessions ensured the tool aligned with the AMP principles: for instance, prioritisation of the health and safety of the community.

Scenario testing of the outcomes was completed to confirm that the approach produces repeatable and consistent results. This was validated through logic tests of the results based on the DEMIRS knowledge of the sites and a comparison against current prioritised programs of work (DEMIRS 2024b).

# 4 Abandoned mines prioritisation

The methodology for prioritisation can be split into four main phases (as illustrated in Figure 1) including the initial data management (including WABMINES and external spatial data) and risk assessment via processing in an FME Workbench. After assessing the risk, the tool prioritises features individually and then groups them into sites for prioritisation.


**Figure 1 Abandoned mines prioritisation workflow**

The following describes each of these phases in further detail.

## 4.1 Data management

The methodology uses two main types of data: the feature attribute information available from WABMINES augmented with updated information as it becomes available, consolidated into an inventory of abandoned mines, and publicly available spatial data.

### *4.1.1 Abandoned Mines Inventory*

The basis of the prioritisation methodology was to use the attribute information available from the WABMINES dataset. The Inventory consists of data points collected from within a 10 km-range of towns and 1 km-range of major roads (Ormsby et al. 2003).

During the development of the prioritisation tool, DEMIRS embarked on an exercise to remap the attribute data captured within WABMINES to account for changes in terminology that have occurred over time (for example, dump versus stockpile) and improve the classification of each of the features by type and sub-type. Within the Inventory and prioritisation methodology a 'feature' is defined as a mining-related feature identified and classified per Table 1. A feature may be a portion (or whole) of an abandoned mine site.

**Table 1 Feature type classification**

| Feature type | Feature sub-types |
|---|---|
| Adit/decline | N/A |
| Combustible carbonaceous shale | N/A |
| Constructed landform | Ash stockpile, borrow pits, leach pad, low-grade stockpile, ore stockpile, overburden stockpile, stockpile, run-of-mine pad rubbish stockpile, topsoil stockpile, tailings storage facility, unconsolidated tailings stockpile |
| Costean/trench | N/A |
| Dam/sump | N/A |
| Drillhole | N/A |
| Infrastructure | Battery, building, chimney, concrete pad/footing,conveyor, headframe, machinery, mill, open areas, other — describe, pipes — describe (e.g. poly, metal), roads/tracks; septic tanks, shaft footing, tanks, winder |
| Pit void | N/A |
| Quarry | N/A |
| Shaft | N/A |
| Shallow working | N/A |
| Subsidence | N/A |

The Abandoned Mines Prioritisation Tool (the Tool) uses selected attribute information from the data available within the Inventory. In particular, the consequence portion of the assessment methodology utilises the depth, height, base condition, feature sub-type, asbestos and heavy metal attribute data.

The input data within the Inventory, from both WABMINES and subsequent publicly reported information, has gaps in the attributes and geometry, and some data captured is in the incorrect format. There are approximately 50,000 records which are unable to be assigned a risk value due to insufficient data.

As the WABMINES data was initially collected from 1999 to 2011, the validity of the information collected cannot be confirmed until site inspections are undertaken. However, this data creates a basis which covers about 76% of the high-priority historic mine sites in WA (DEMIRS 2024a).

### *4.1.2 Spatial data*

External spatial data is used to identify the proximity of each feature to sensitive receptors (e.g. current active schools or nationally important wetlands) or additional information (e.g. the feature is located on a live mining tenement). These external GIS databases are published by reputable sources such as Landgate and the Department of Planning, Lands and Heritage. The datasets are all publicly available on Data WA (https://www.data.wa.gov.au/), apart from the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Areas, which is a national dataset (Department of Climate Change, Energy, the Environment and Water 2023).

The Tool uses the data in Table 2 for four main analyses:

**Health and safety** — the likelihood of people being exposed to a health and safety hazard from a feature. The Tool considers townsites, points of interest (such as tourism locations) and schools.

**Environment** — the likelihood the of natural world being exposed to an environmental hazard from a feature, including flora and fauna, or from the physical surroundings, like wetlands or World Heritage Sites.

**Community** — the likelihood of groups of individuals and sites of cultural importance being exposed to hazards from a feature. Community also includes heritage, which involves assessing impacts on places that alter or diminish their cultural significance.

The Tool also provides additional information about feature locations to enhance understanding, such as the closest town or if it is located on a current mining tenement.

**Table 2 External spatial data sources**

| Health/safety | Environment | Community | Additional information |
|---|---|---|---|
| Townsites (LGATE-248) (Landgate 2024a) | Clearing regulations — environmentally sensitive areas (DWER-046) (Department of Water and Environmental Regulation 2024) | Aboriginal Heritage Places (DPLH-099) (Department of Planning, Lands and Heritage 2024a) | Cadastre (Polygon) (LGATE-217) (Landgate 2024c) |
| Medium-scale Topo points of interest (LGATE-135) (Landgate 2024b) | Threatened ecological communities (DBCA-038) (Department of Biodiversity, Conservation and Attractions, 2024a) | Heritage Council WA — State Register (DPLH-006) (Department of Planning, Lands and Heritage, 2024b) | Mining tenements (DMIRS-003) (DEMIRS 2024c) |
| Current active schools semester 1 2023 – public (DET-021) (Department of Education 2023) | Threatened and priority flora (DBCA-036) (Department of Biodiversity, Conservation and Attractions 2024b) | Heritage Council WA — Local Heritage Survey (DPLH-008) (Department of Planning, Lands and Heritage 2024c) | Townsites (LGATE-248) (Landgate 2024a) |
| | Threatened and priority fauna (DBCA-037) (Department of Biodiversity, Conservation and Attractions 2024c) | | |
| | Ramsar sites (DBCA-010) (Department of Biodiversity, Conservation and Attractions 2024d) | | |
| | Directory of Important Wetlands in Australia — WA (DBCA-045) (Department of Biodiversity, Conservation and Attractions 2024e) | | |
| | UNESCO World Heritage Areas (Department of Climate Change, Energy, the Environment and Water 2023) | | |

## 4.2 Risk assessment

The risk assessment process was developed using the FME Form produced by Safe Software (Safe Software 2023). FME is specialised software for geospatial data analysis, transformation and integration. By leveraging FME Form, an automated and repeatable process was established to assign risk categories as new sites or attributes are updated in the master Inventory dataset.

Fundamentally this tool relies on a standard risk assessment which is a fundamental aspect of risk management. It evaluates risks by considering both likelihood and consequence. Likelihood assesses the probability of a risk event occurring while consequence evaluates the impact or severity of such an event.

The risk assessment considers health, safety, environment and community impacts.

### *4.2.1 Likelihood*

The Tool calculates likelihood or the qualitative assessment that explains how likely a risk will occur, based on proximity to sensitive receptors. The underlying assumption is that the closer a feature is to a sensitive receptor (such as schools or environmentally sensitive areas) the more likely there is to be an interaction with that feature that could lead to an undesired outcome.

Included in the Tool is a secondary likelihood modifier which considers how additional attributes might impact on the likelihood of an undesired outcome. Therefore, the risk assessment considers factors such as the stability of working edges and the visibility of a site.

Visibility serves as an example of the Tool's automation process and is designed for minimise bias. For instance, when assessing a site that is visible, one individual might classify it as high-risk due to its visibility being an incentive to visit. In contrast, another assessor might view visibility as a low risk, recognising that individuals can intentionally avoid inadvertent incidents.

Specific criteria were established to give each feature a likelihood score based on its proximity to the defined receptor types. In general, the closer a feature is to a receptor, the higher the score. The distance criteria are specific to each type of receptor. For example, the highest likelihood score for health and safety is based on a greater distance than for environment (1 km versus 100 m, respectively), given the ability for people to use various modes of transport to travel to a feature compared to a feature's ability to encroach onto a sensitive environmental receptor. As the receptor distance increases from the feature, the likelihood score is reduced using a one to five rating system.

The rationale applied to the distances used for the highest likelihood score is provided in Table 3.

**Table 3 Likelihood score rationale**

| Category | Likelihood receptor | Distance for highest likelihood score | Rationale |
|---|---|---|---|
| Health and safety | Town population | 1 km | People will always be present and have the ability to use multiple modes of transport to reach an abandoned mine feature |
| Health and safety | Tourism location | 500 m | Transient population visiting the area for a specific purpose are likely to be on foot in proximity to the tourism point |
| Health and safety | School | 1 km | People are present much of the year and in transit twice per day. Potentially curious unsupervised children are in transit |
| Environment | Environment | 100 m | Due to the nature of the abandoned features, there is typically a limited capacity for them to encroach on an environmental or heritage receptor |
| Community | Heritage | 100 m | |

### *4.2.2 Consequence*

While likelihood was predominantly defined by external spatial databases, consequence was related to the feature's attributes available in the Inventory. The consequence values for safety, health, environment and community were defined based on the following assumptions:

- The safety consequence is determined by the depth, height or base conditions of a feature. This assumption is based on the understanding that these factors directly impact the severity of potential injuries.

- The health consequence is determined by a feature containing asbestos or heavy metals. This assumption is based on the understanding that these factors can cause long-term illnesses and diseases, or deleterious health effects; noting, however, that the Inventory does not currently contain information relating to the presence of heavy metals or asbestos, and therefore health consequences cannot be assessed until such data is populated (the methodology allows for this in the future).
- The environment consequence is determined by the feature containing tailings or refuse/rubbish. This assumption is based on the understanding that these factors can contaminate the local environment.
- Unlike the other factors, community consequence cannot be determined without stakeholder engagement. Therefore, it receives an automatic score of one to account for any features that are in proximity to a heritage location.

The scoring criteria for consequences was based on the principle that the more severe the potential consequence, the higher the score using a one to seven rating system. For example, shafts with a greater depth will receive a higher score than those that are shallow due to the greater potential for a fatality in an extremely deep excavation versus a shallow one.

## 4.3 Feature prioritisation

The risk of each feature is calculated by the multiplication of the likelihood and consequence scores for each of the respective health, safety, environment and community outcomes; providing a numerical value risk score for each outcome type.

The risk scores for each of the four outcomes are then added together to provide the total feature risk score.

In general, a feature that is near a sensitive receptor and has attributes that have the potential to result in more severe consequences will have the highest feature risk score.

From the total feature risk score, the features are grouped into four risk categories — extreme, high, medium and low — to allow for prioritisation of individual features.

By providing the health, safety, environment and community risk score in addition to the total feature risk score, the outputs allow for determining the factor driving the risk scores. For example, the total risk for a feature may be due to having a combination of health, safety, environment and community risks or it could be due to a dominant safety risk.

## 4.4 Site prioritisation

While it is informative to identify the highest risk features, the ranking of more than 190,000 individual features is unmanageable for the prioritisation of AMP projects. Therefore, a secondary step is used to prioritise the features into sites using a 1 $km^2$ grid. The site risk scores are derived from the combination of individual feature risk scores within the grid. Unlike the features, the sites are categorised into priority one, two, three or four.

In Figure 2, an ArcGIS export depicts features as small circles and sites on a grid (ESRI 2024). These features and sites are colour-coded, with dark green representing the lowest risk, or priority four, and red indicating extreme risk, or priority one. The number in the middle of the site is also used to identify the number of features within the 1 $km^2$ site.

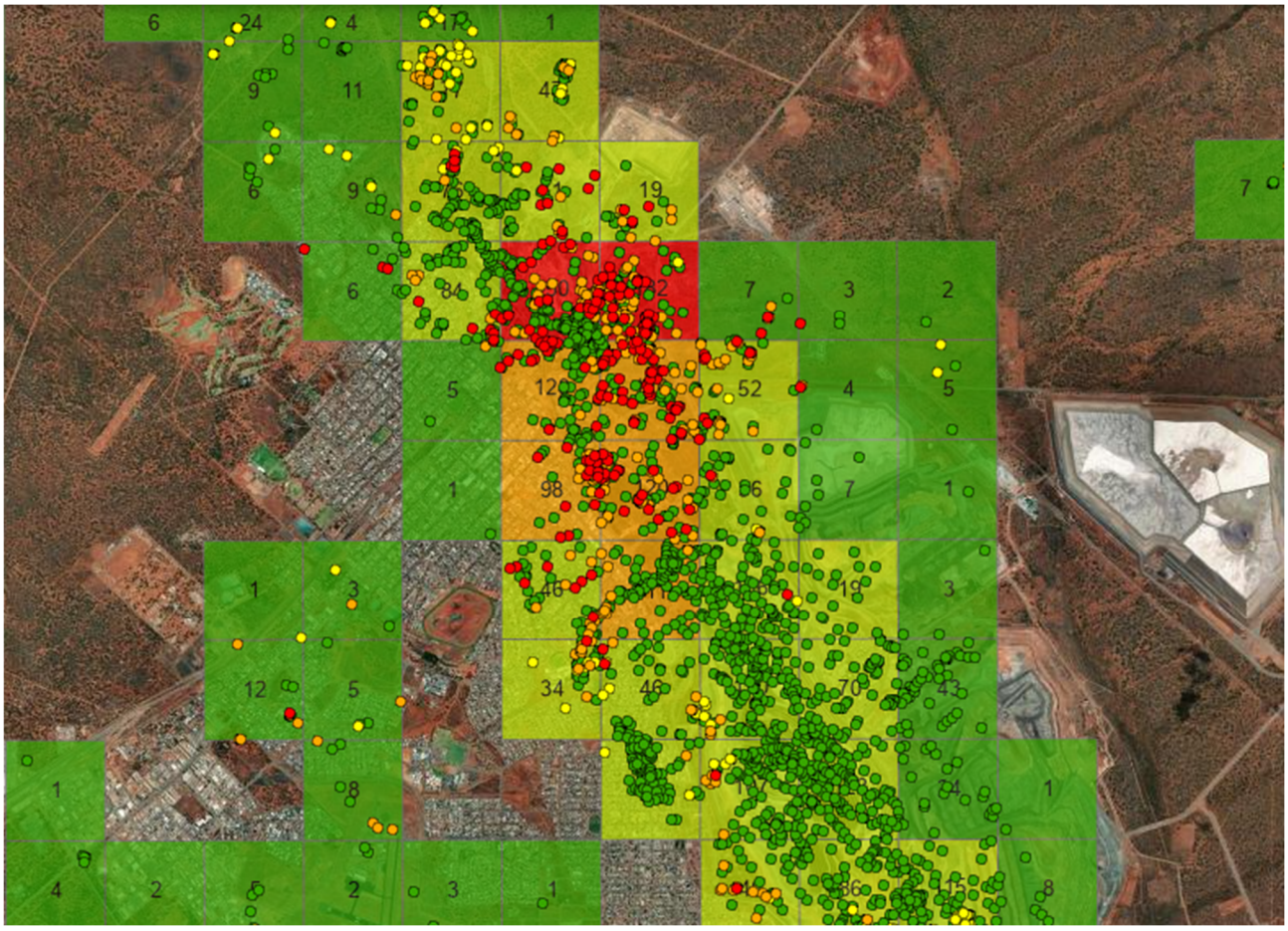

**Figure 2 Example of an abandoned feature and site prioritisation**

Following the desktop prioritisation of abandoned mine features and sites, preliminary on-ground inspections and stakeholder engagement are conducted to confirm the information used in the desktop assessment and to commence project definition.

The risk-based prioritisation methodology, with outputs for both individual features and groups of features, enables the prioritisation of individual features but also of specific areas or locations based on the cumulative health, safety, environment and community risks.

While it is recognised that the outputs of the desktop assessment are not absolute, the combined-feature, site-based prioritisation provides an approach to enable the development of cost-effective projects to address significant risks in the vicinity of given locations.

# 5 Future development

## 5.1 Data updates

The Tool has been developed to allow the inclusion of new features and incorporate updates to the attributes of features already captured within the database. For example, no information is currently held regarding heavy metal and asbestos status for the health risk assessment, however, the Tool has been developed with this information category being available for future use. The prioritisation methodology also employs published spatial data that may be updated over time to enable periodic update of the assessment and re-prioritisation of the features and sites as new information becomes available.

A detailed procedure has been developed outlining the methodology, governance of data and change management requirements such that the Tool provides a robust, repeatable, and fully transparent process, particularly as new information becomes available.

### 5.2 Live WebGIS environment

DEMIRS is planning upgrades to the WebGIS environment over the next two years. An FME Workbench was chosen for the Tool to allow ease of integration into the new WebGIS environment when it is established, while also preventing delays to the development of the Tool based on other project timelines.

Upon development of the new WebGIS environment the Tool can be transitioned to an online solution built on the Geocortex platform, which would provide the following benefits:

- creation of a single source for all current risk assessment data
- integration with 'live' GIS data
- direct data entry by DEMIRS staff and contractors (depending on licence agreements)
- development of dashboards and map-based visualisations for risk management and reporting
- enabling of field-based data entry directly into the database using Survey 123
- enforcement of data standards
- visualisation of risk changes over time.

## 6 Conclusion

This paper has provided an overview of the Abandoned Mines Prioritisation Tool developed to prioritise high-risk abandoned mine features for management and/or rehabilitation under the AMP.

The prioritisation methodology has been developed using a risk-based approach that is robust, repeatable and fully transparent to all AMP stakeholders. The Tool allows for the editing of feature attributes and the inclusion of new features, and has broadened the assessment approach to consider environmental and community risks in addition to public health and safety. It has also incorporated the ability to prioritise individual features and specific areas or locations, based on a group of features.

The prioritisation methodology and the Tool provide a leading practice approach for the prioritisation of abandoned mine sites to progress them to a rehabilitation project stage.

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## References

DEMIRS ca. 2021, *About the Program*, viewed 8 June 2024, https://www.dmp.wa.gov.au/Geological-Survey/About-the-Program-32024.aspx

DEMIRS 2024a, *Inventory of Abandoned Mine Sites Database*, viewed 7 June 2024, https://warsydprdstadasc.blob.core.windows.net/downloads/Metadata_Statements/XML/METADATA_ABM_AbandonedMines_GDA1994.xml?ts=20240603124242

DEMIRS 2024b, *Projects*, viewed 10 June 2024, https://www.dmp.wa.gov.au/Geological-Survey/Program-projects-29315.aspx

DEMIRS 2024c, *Mining tenements (DMIRS-003),* data WA, https://catalogue.data.wa.gov.au/dataset/mining-tenements-dmirs-003

Department of Biodiversity, Conservation and Attractions 2024a, *Threatened Ecological Communities (DBCA-038),* data WA, https://catalogue.data.wa.gov.au/dataset/threatened-ecological-communities

Department of Biodiversity, Conservation and Attractions 2024b, *Threatened and Priority Flora (DBCA-036),* data WA, https://catalogue.data.wa.gov.au/dataset/threatened-and-priority-flora

Department of Biodiversity, Conservation and Attractions 2024c, *Threatened and Priority Fauna (DBCA-037),* data WA, https://catalogue.data.wa.gov.au/dataset/threatened-and-priority-fauna

Department of Biodiversity, Conservation and Attractions 2024d, *Ramsar Sites (DBCA-010),* data WA, https://catalogue.data.wa.gov.au/dataset/ramsar-sites

Department of Biodiversity, Conservation and Attractions 2024e, *Directory of Important Wetlands in Australia — WA (DBCA-045),* Data WA, https://catalogue.data.wa.gov.au/dataset/directory-of-important-wetlands-in-western-australia

Department of Climate Change, Energy, the Environment and Water 2023, *Australia World Heritage Areas*, viewed 8 June 2024, https://fed.dcceew.gov.au/datasets/bd46da1431cc4250b6be4017958fc1c6/about

Department of Education 2023, *Current Active Schools Semester 1 2023 – Public (DET-021)*, data WA, https://catalogue.data.wa.gov.au/dataset/current-active-schools-semester-1-2023-public-det-021

Department of Planning, Lands and Heritage, 2024a, *Aboriginal Heritage Places (DPLH-099),* data WA, https://catalogue.data.wa.gov.au/dataset/aboriginal-cultural-heritage-register

Department of Planning, Lands and Heritage 2024b, *Heritage Council WA — State Register (DPLH-006),* data WA, https://catalogue.data.wa.gov.au/dataset/heritage-council-wa-state-register

Department of Planning, Lands and Heritage 2024c, *Heritage Council WA — Local Heritage Survey (DPLH-008),* data WA, https://catalogue.data.wa.gov.au/dataset/municipal-inventory-sho-005

Department of Water and Environmental Regulation 2024, *Clearing Regulations - Environmentally Sensitive Areas (DWER-046)*, data WA, https://catalogue.data.wa.gov.au/dataset/clearing-regulations-environmentally-sensitive-areas-dwer-046

DMP 2016, *Abandoned Mines Policy*, Perth.

ESRI 2024, *ArcGIS*, computer software, Brisbane, https://www.esri.com/en-us/arcgis/about-arcgis/overview

GHD 2005, *WA Abandoned Mines Risk Assessment Model – Risk Assessment Guidance Manual*, Perth.

Government of Western Australia 2012, *Mining Rehabilitation Fund Act*, Perth.

ISO 2018, *Risk Management - Guidelines (ISO 31000)*, Geneva.

Landgate 2024a, *Townsites (LGATE-248)*, data WA, https://catalogue.data.wa.gov.au/dataset/townsites

Landgate 2024b, *Medium Scale Topo Points of Interest (LGATE-135)*, data WA, https://catalogue.data.wa.gov.au/dataset/medium-scale-points-of-interest-lgate-135

Landgate 2024c, *Cadastre (Polygon) (LGATE-217)*, data WA, https://catalogue.data.wa.gov.au/dataset/cadastre-polygon

Mitchell, I, Hryczyszyn, K & Read, T 2019, 'A framework to prioritise high-risk abandoned mine features for rehabilitation in Western Australia', in AB Fourie & M Tibbett (eds), *Mine Closure 2019: Proceedings of the 13th International Conference on Mine Closure*, Australian Centre for Geomechanics, Perth, pp. 123–132, https://doi.org/10.36487/ACG_rep/1915_11_Mitchell

Ormsby, WR, Howard, HM & Eaton, NW 2003, *Inventory of Abandoned Mine Sites: Progress 1999–2002*, Geological Survey of Western Australia, Department of Industry and Resources, Perth.

Safe Software 2023, *FME Form*, computer software, https://academy.safe.com/page/fme-form