BULLI SEAM OPERATIONS

SECTION 6
REHABILITATION AND MINE CLOSURE

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6 REHABILITATION AND MINE CLOSURE

This section provides a description of the proposed rehabilitation strategy for the Project, including:

- closure and rehabilitation of the West Cliff, Appin East and Appin West pit top areas (Section 6.1.1);
- decommissioning and/or rehabilitation of the Appin No. 1, No. 2 and No. 3 shaft sites, North Cliff shafts site and Bulli shafts site (Section 6.1.2);
- decommissioning and rehabilitation of the West Cliff Stage 4 Coal Wash Emplacement (Section 6.2);
- rehabilitation of temporary surface disturbance areas (Section 6.3); and
- rehabilitation of subsidence impacts on natural surface features (Section 6.4).

Section 6.5 describes mine lease relinquishment.

Under the *Mining Act, 1992*, environmental protection and rehabilitation are regulated by conditions included in all Mining Leases, including requirements for the submission MOPs and AEMRs. Collectively, the MOP and AEMR constitute the *Guidelines to the Mining, Rehabilitation and Environmental Management Process* (MREMP Guidelines) (DPI-MR, 2006) which has been developed by the DPI-MR. The MOP and AEMR are discussed further in Section 7. As Project rehabilitation activities would be undertaken progressively, the MREMP framework would be used throughout the Project life to both plan and track the performance of these activities as they are carried out.

6.1 MINE CLOSURE PLANS FOR PIT TOP AREAS AND SHAFT SITES

BHP Billiton's company wide closure standard requires all BHP Billiton controlled operations to have closure plans which are regularly reviewed and updated and which identify, mitigate where practicable, and manage both current and future health, safety, environment and community, and other business risks associated with closure (BHP Billiton, 2004b).

An overview of mine closure planning for the West Cliff, Appin East and Appin West pit tops is provided in Section 6.1.1. An overview of mine closure planning for the Appin No. 1, No. 2 and No. 3 shaft sites, North Cliff shafts site and Bulli shafts site is provided in Section 6.1.2.

Further investigations would be conducted nearer to the end of the Project life to further inform mine closure planning. The investigations would include: geotechnical investigations; land contamination investigations; hazardous materials investigations; non-Aboriginal heritage studies; water flow and quality assessment (e.g. Brennan's Creek Dam); risk assessment; the preparation of detailed rehabilitation plans; and the preparation of detailed engineering design and construction drawings.

Stakeholder consultation is recognised as an important component of the mine closure process. A stakeholder consultation strategy specific to closure would be developed and implemented at an appropriate time prior to Project closure and would include consideration of potential adverse socio-economic effects due to a reduction in employment (Section 5.16.3).

6.1.1 Pit Top Areas

West Cliff Pit Top

The existing West Cliff pit top is located off Appin Road to the south-east of Appin village (Figure 2-1).

Existing surface infrastructure at the West Cliff pit top includes: a drift portal; upcast ventilation shaft (No. 1) and fan house; downcast ventilation shaft (No. 2) and winder building; gas drainage, capture and beneficiation equipment; including WestVAMP; coal drift and conveyor; product coal bins; ROM and product coal stockpiles and handling areas; CPP and associated conveyors, transfer points and buffer bins; coal wash emplacements; product coal road transport loading facilities; internal haul roads; administration offices and bath house; stores and workshop facilities; and other ancillary infrastructure (e.g. diesel/oil tanks/storage, pumps and pipelines, compressors, gasometer structure and electrical substations) (Figure 2-2).

Existing water management infrastructure at the West Cliff pit top includes the Brennans Creek Dam, water treatment ponds, water collection and settlement ponds and tanks, irrigation area, water diversions, and water reticulation systems (e.g. tanks, pumps and pipelines).

Appin East Pit Top

The existing Appin East pit top is located off Appin Road to the south-east of Appin village (Figure 2-1).

Existing surface infrastructure at the Appin East pit top includes: men and materials drift and winder; downcast ventilation and main coal drift and drive house; coal handling infrastructure (e.g. conveyors, hoppers and bins); ROM coal bins, stockpile area and truck loading facilities; administration complex and bath house; workshop facilities, stores and storage areas; water management/treatment facilities (e.g. ponds/lagoons, dams, filter and dosing plants); internal haul roads; and other ancillary infrastructure (e.g. water/waste water/diesel/oil tanks, pumps and pipelines, compressors, electricity substation and explosives storage) (Figure 2-3).

Appin West Pit Top

The existing Appin West pit top is located off Douglas Park Drive approximately 4 km south of Douglas Park township (Figure 2-1).

Surface facilities at the Appin West pit top include: men and materials winder; two downcast ventilation shafts; administration office; employee facilities and bathhouse; workshop and storage areas; coal loading infrastructure (currently not in use); methane drainage plant including gas pipe system and exhauster house; water management/treatment infrastructure (e.g. water treatment facility; water tanks; surface water runoff holding lagoons; and mine water and stabilisation lagoons); other ancillary infrastructure (e.g. diesel/oil tanks; pumps and pipelines; compressors; and electrical substation); and components of the Appin-Tower Power Project infrastructure (managed by EDL) (Figure 2-4).

Mine Closure Plans

Mine Closure Plans have been prepared for the West Cliff, Appin East and Appin West pit tops (Cardno Forbes Rigby, 2006a, 2006b, 2006c). The plans provide conceptual closure plans in recognition of the proposed extension to the mine life (and associated pit top use) of some 30 years.

The West Cliff Colliery is located on leased Crown Land adjacent to a SCA Special Area and the Dharawal State Conservation Area, and the final landuse of natural bushland is proposed for the site (Cardno Forbes Rigby, 2006a). A final landuse of residential development is proposed for the Appin East and Appin West pit tops (Cardno Forbes Rigby, 2006b, 2006c).

However, in recognition of the location and setting of these areas and the potential benefits of alternative uses such as light industrial or other employment-generating activities, the proposed final landuses will be reviewed over the mine life in consultation with government and community stakeholders.

The Mine Closure Plans would be reviewed and revised throughout the Project and be finalised prior to mine closure.

At mine closure, on the ground works would include the removal of infrastructure, the sealing of mine entrances and land rehabilitation (Cardno Forbes Rigby, 2006a, 2006b, 2006c).

Work anticipated being required at the pit tops includes (Cardno Forbes Rigby, 2006a, 2006b, 2006c):

- removal of underground infrastructure such as mining equipment and service infrastructure;
- sale of underground equipment or transfer to other BHP Billiton mines;
- removal of pit top buildings (e.g. administration offices, bathroom, survey office, water tanks, and various demountable buildings);
- removal of other infrastructure (e.g. diesel tanks, soluble oil tanks, waste oil tank, workshop, store building, various storage sheds/pump houses and hoppers);
- removal of coal loading equipment (e.g. bulk coal winder, conveyor gantry, old ventilation fans, compressor building, coal loading bins and weighbridge);
- removal of methane drainage plant equipment (e.g. pump seal tanks, switch room, fencing, exhauster houses, automatic fire protection systems, and underground methane pipelines that lead to the EDL gas engine plant). Note, however that this infrastructure may need to remain in place for a significant time after closure to manage gas drainage or for continued gas supply to the EDL power plant;
- removal of sewage treatment facilities (e.g. sewage treatment plant, stabilisation ponds, and poly pipe used to distribute treated effluent) and backfill of the stabilisation ponds;
- testing and remediation of any contaminated soil by removal, encapsulation or landfarming on-site;
- backfill of mine water lagoons/dams;

- removal of water treatment facilities (e.g. desalination plant, acid dosing plant, carbon filter, monitoring pit, old sand storage, and spillways), removal of filtration material and backfill of filter lagoons;
- removal of infrastructure associated with water release points and stabilisation of discharge points and drainage lines to prevent erosion into Sandy Gully (Allens and Clements Creeks), Brennans Creek and Georges River;
- rehabilitation of the Brennans Creek dam site;
- removal of water irrigation pipelines, including recycled water lines;
- filling and sealing of men and materials shafts and bulk coal winding shafts in accordance with DPI requirements;
- removal or encapsulation of concrete slabs;
- removal of bitumen surfaces, pipelines, power lines and associated services;
- re-profiling of the sites in accordance with the final landform design;
- topsoiling of bare or stripped areas; and
- revegetation of the sites in accordance with the final revegetation/landscape plans using local species. This may include ripping and seeding to stabilise bare soil using an appropriate method (such as hydroseeding/ hydromulching).

Maintenance and monitoring plans would be developed to assess the performance of the rehabilitation at each pit top site. For example, monitoring would be undertaken to confirm vegetation is establishing and to determine the requirement for the implementation of maintenance measures (e.g. implementation of weed control measures or replanting/reseeding).

The Mine Closure Plans (Cardno Forbes Rigby, 2006a, 2006b, 2006c) include a conceptual Rehabilitation Plan for each pit top.

In accordance with Approval Conditions for the West Cliff Colliery CPP Project, the CPP would be decommissioned and rehabilitated to the satisfaction of the DPI following the completion of mining related activities at the West Cliff pit top.

In accordance with Approval Conditions for the West Cliff Colliery Surface Goaf Gas Drainage Project, a Vegetation Clearing and Rehabilitation Protocol would be developed to the satisfaction of the Director-General of DoP and would describe the procedures for revegetating and rehabilitating the areas of disturbance associated with the Surface Goaf Gas Drainage Project. These same procedures would be adopted for any other surface goaf gas drainage sites developed for the Project.

The Appin-Tower Power Project infrastructure is owned by EDL and would be rehabilitated by EDL. The closure of the power plant may not occur at the same time as pit top closure. There is potential for the continued supply of mine gas and or natural gas to the facility after mine closure.

6.1.2 Shaft Sites

Appin No. 1 and No. 2 Shafts Site

The Appin No. 1 and No. 2 shafts and fan site is located approximately 2 km west of the Appin East pit top (Figure 2-1). Infrastructure at the site includes: a downcast ventilation shaft (Appin No.1); upcast ventilation shaft (Appin No. 2) and fan house; gas drainage plant including gas drainage pipe system and surface exhauster house; workshop and store rooms; water management infrastructure (e.g. water tanks and site runoff collection ponds); and electrical switchroom and switchyard (Figure 2-5).

The Mine Closure Plan for the Appin East pit top describes closure and rehabilitation of the Appin No. 1 and 2 Shafts site. Work anticipated being required at the shafts site includes (Cardno Forbes Rigby, 2006b):

- removal of infrastructure (e.g. exhaust fans and their housings and ducting, diesel fan generator, switch/cable room and generator, administration offices, site shed, water tanks, drainage infrastructure and roadway, hardstand and foundations, substation and power poles);
- remediation of any contaminated soil by removal, encapsulation or landfarming on-site;
- filling and sealing of the uptake and downcast shafts in accordance with DPI requirements;
- re-profiling of the site in accordance with the final landform design;

- topsoiling of bare or stripped areas; and
- revegetation of the site in accordance with the final revegetation/landscape plan using local species. This may include ripping and seeding to stabilise bare soil using an appropriate method (such as hydroseeding/ hydromulching).

Maintenance and monitoring plans would be developed to assess the performance of the rehabilitation. Monitoring would be undertaken to confirm vegetation is establishing and the need for maintenance measures (e.g. implementation of weed control measures).

Appin No. 3 Shaft Site

The Appin No. 3 shaft (former Tower No. 3) and fan site is located approximately 4 km west of Appin village (Figure 2-1). Infrastructure at the site includes: upcast ventilation shaft and fan houses; workshop and switch room; water management/treatment infrastructure (e.g. water tank, septic tanks and retention pond); and electrical substation (Figure 2-5).

The Mine Closure Plan for the Appin West pit top describes closure and rehabilitation of the Appin No. 3 shaft site. Work anticipated being required at the shaft site includes (Cardno Forbes Rigby, 2006c):

- removal of infrastructure (e.g. exhaust fans and their housings and ducting, switch/cable room, roadway, hardstand and foundations, substation and power poles);
- remediation of any contaminated soil by removal, encapsulation or landfarming on-site;
- filling and sealing of the uptake shaft in accordance with DPI requirements;
- re-profiling of the site in accordance with the final landform design;
- topsoiling of bare or stripped areas; and
- revegetation of the site in accordance with the final revegetation/landscape plan using local species. This may include ripping and seeding to stabilise bare soil using an appropriate method (such as hydroseeding/ hydromulching).

Maintenance and monitoring plans would be developed to assess the performance of the rehabilitation. Monitoring would be undertaken to confirm vegetation is establishing and the need for maintenance measures (e.g. implementation of weed control measures).

North Cliff Shafts Site

The existing North Cliff shafts are located approximately 5 km east of the West Cliff pit top (Figure 2-1). Infrastructure at the site includes: two shafts (No. 3 and No. 4) and associated winder houses; access and internal roads; shed; and spoil stockpile and sediment dam (Figure 2-5).

The Mine Closure Plan for the West Cliff Colliery describes closure and rehabilitation of the North Cliff shafts site. Work anticipated being required at the shaft site includes (Cardno Forbes Rigby, 2006a):

- removal of infrastructure (e.g. sheds, winder houses, concrete and steel water/septic tanks, steel frames and ventilation fan ducting, fencing and power lines and poles);
- removal of temporary shaft seals;
- filling and sealing of the shafts in accordance with DPI requirements;
- remediation of any contaminated soil by removal, encapsulation or landfarming on-site;
- backfilling of lagoon;
- re-profiling of the site in accordance with the final landform design;
- topsoiling of bare or stripped areas; and
- revegetation of the site in accordance with the final revegetation/landscape plan using local species. This may include ripping and seeding to stabilise bare soil using an appropriate method (such as hydroseeding/ hydromulching).

Maintenance and monitoring plans would be developed to assess the performance of the rehabilitation. Monitoring would be undertaken to confirm vegetation is establishing and the need for maintenance measures (e.g. implementation of weed control measures).

Bulli Shafts Site

The Bulli Shafts site is located in the south-east of CCL 767 in lands managed by the SCA and consists of four (No.1 to No.4) disused shafts (Figure 1-1). These shafts have previously been sealed to DPI-MR standards. The shafts would be rehabilitated during the life of the Project.

The Bulli No. 1 and No. 2 Shafts have been assessed as having regional heritage significance and if final rehabilitation works include removal of these structures, the majority of the heritage fabric would be removed. ICHPL would consult with the SCA regarding the future management and conservation of the Bulli No. 1 and No. 2 Shafts.

The Bulli No. 1 and No. 2 Shaft heritage items would remain *in-situ* unless unresolvable public safety issues dictate their removal. In the event the items are retained in their original position, ICHPL would consult with the SCA on the development and implementation of a management plan for the long-term conservation of the heritage listed items, with advice from other relevant authorities (e.g. Heritage Branch of the DoP). Should conservation of either or both of these items not prove to be feasible or prudent, full recording to the standard required by the Heritage Branch of the DoP for items of regional significance would be carried out prior to removal of all or part of the items.

Bulli Shafts No. 3 and No. 4 are not considered to have any heritage significance (Appendix H).

Work anticipated as being required at the Bulli Shaft No. 3 includes (Cardno Forbes Rigby, 2006b; Sheldrill, 2008):

- removal of surface structures (e.g. concrete brick fan drift, axial flow fan, brick evase and motor house);
- removal of all concrete foundations;
- removal of temporary shaft seal;
- filling and sealing of the shaft in accordance with DPI requirements;
- remediation of any contaminated soil if required by removal, encapsulation or landfarming on-site;
- re-profiling and ripping of disturbed areas of the site in accordance with the final landform design; and
- revegetation in accordance with the final revegetation/landscape plan utilising local species.

The Bulli Shaft No. 4 has been the subject of recent consultation (June 2009) with the DPI-MR, WCC and SCA. The Bulli Shaft No. 4 was backfilled and capped with a concrete slab in 1985 (Sheldrill, 2008).

The following measures are currently proposed for Bulli Shaft No. 4:

- retainment of concrete slab capping and settling pond;
- drilling of holes in the up-hill concrete slabs to encourage re-establishment of soil and vegetation;
- removal of screws/bolts from concrete slabs;
- removal of the brick switchroom;
- removal of concrete material from switchyard; and
- retaining of some power poles and removal of others.

Stakeholder consultation would be undertaken as part of the preparation of the Rehabilitation Plan for the Bulli Shaft No. 4.

6.2 WEST CLIFF STAGE 4 COAL WASH EMPLACEMENT

The West Cliff Coal Wash Emplacement has been designed to progress gradually down the valley of the contained Brennans Creek Dam catchment. Figures 2-2 and 2-15 show the locations of Stages 1 to 4 of the Coal Wash Emplacement.

Stage 1 of the Coal Wash Emplacement commenced in 1976 and was completed in 2001. Stage 1 is currently undergoing rehabilitation. Stage 2 of the Coal Wash Emplacement commenced in 2000 and it is anticipated that Stage 2 would reach its final landform in 2009/2010. Progressive rehabilitation of completed sections of the Coal Wash Emplacement has commenced. The active emplacement area is kept to a practicable minimum and as each section of fill reaches the designed height and landform, topsoil is applied and revegetation works are implemented.

ICHPL obtained a Notice of Staged Development Approval in December 2007 for the development of Stage 3 of the Coal Wash Emplacement in accordance with the requirements of the Development Consent (DA 60-03-2001) for the Dendrobium Mine. The maximum design height for Stage 3 is approximately 353 m AHD. Based on the maximum planned production rate, coal wash produced by the Project during the first ten years of the Project life would be placed in the Stage 3 Coal Wash Emplacement in accordance with the Stage 3 Coal Wash Emplacement Management Plan (Cardno Forbes Rigby, 2007a).

Subject to the outcomes of further engineering and feasibility studies as part of the underground emplacement pilot trial (Section 2.8.4) and ongoing consideration of alternative coal wash management options (Section 2.8.5), coal wash produced by the Project would be placed at the Stage 4 Coal Wash Emplacement (Figure 2-15). The maximum design height for Stage 4 is approximately 365 m AHD, with a maximum valley fill depth of approximately 88 m. A cross-section of the conceptual design of the Stage 4 Coal Wash Emplacement is shown on Figure 2-15.

High density polyethylene pipe is currently used for underground drainage for the West Cliff Coal Wash Emplacement. ICHPL has considered potential engineering options (e.g. reinforcement installation or steel pipes) for underdrainage water management for the increased emplacement height. ICHPL would prepare a West Cliff Stage 4 Coal Wash Emplacement Management Plan that would detail the preferred underdrainage water management system for the Stage 4 Coal Wash Emplacement.

The West Cliff Stage 4 Coal Wash Emplacement would be progressively rehabilitated. Rehabilitation activities for the Stage 4 Coal Wash Emplacement would be consistent with current practices implemented for adjoining stages of the Coal Wash Emplacement.

The West Cliff Stage 4 Coal Wash Emplacement Management Plan would include the following measures applicable to rehabilitation of the Coal Wash Emplacement:

- native seed would be harvested from areas of land proposed to be cleared for the Coal Wash Emplacement and used in the rehabilitation of completed emplacement areas;
- vegetative material would be harvested from areas of land proposed to be cleared for the Coal Wash Emplacement and used as mulch or brush matting in the rehabilitation of completed emplacement areas;
- soil would be stripped from areas of land proposed to be cleared for the Coal Wash Emplacement and used in the rehabilitation of completed emplacement areas;
- the completed emplacement surface would be shaped to even grades and to mimic micro-topographic features (e.g. slopes and contours for drainage) prior to the spread of topsoil;
- stripped soil would be applied over completed areas of the emplacement. Seed rich topsoil would be re-used as quickly as possible;
- where practicable, soil stockpiling would be avoided, with stripped soil layers being immediately re-distributed to completed emplacement areas following stripping. However, it is noted that when the emplacement is progressing to its final stages, particular attention would be paid to stockpiling the necessary volumes of soil to achieve adequate soil cover of the final landform;
- erosion and sediment control measures would be installed, where appropriate;
- cultivated endemic plant species using flora species characteristic of the previously disturbed vegetation communities would be planted;
- propagated *P. hirsuta* plants would be planted in the rehabilitation of the Stage 4 Coal Wash Emplacement on suitable topsoiled areas;
- habitat features would be established for potential use by native fauna (e.g. addition of logs and other woody debris, reconstruction of rocky outcrops, etc.);
- the management strategies outlined in the Broad-headed Snake Management Plan (Biosis Research, 2007e) would be implemented for the Stage 4 Coal Wash Emplacement; and
- potentially suitable habitat for the Southern Brown Bandicoot would be established (e.g. a dense and contiguous understorey of vegetation) to provide potential cover for the bandicoots to forage and potential nesting materials for shelter.

A monitoring programme would be developed and included in the West Cliff Stage 4 Coal Wash Emplacement Management Plan. Consistent to those measures included in the West Cliff Stage 3 Coal Wash Emplacement Management Plan (Cardno Forbes Rigby, 2007a), the monitoring programme would include monitoring of groundwater, temperature, emplacement settlement, compaction and combustibility, sub-surface drainage including flow rate and water quality, water quality in water management structures, erosion and sediment controls, vegetation, fauna habitats and dust generation.

Maintenance measures would be implemented as required and may include supplementary plantings of local provenance tubestock, weed control measures and erosion and sediment control measures.

6.3 TEMPORARY SURFACE DISTURBANCE AREAS

Surface disturbance works associated with supporting infrastructure for the Project are described in Section 2 and would include: exploration works; installation of surface infrastructure; construction and/or management of access tracks required for the installation/ maintenance of surface infrastructure; subsidence monitoring, subsidence remediation works and other minor Project-related surface activities. The final location of some of the ancillary infrastructure and surface works would be determined as part of the detailed mine design. The location of ancillary infrastructure and surface works would be reported in the relevant Extraction Plan.

ICHPL would prepare a Rehabilitation Management Plan for these surface disturbance works in consultation with the relevant landholders and stakeholders (e.g. the SCA for rehabilitation of surface disturbance areas in the Metropolitan, O'Hares Creek and Woronora Special Areas and the DECC for rehabilitation of surface disturbance areas in the Dharawal State Conservation Area), and to the satisfaction of the Director-General of the DoP. It is anticipated that the preparation and implementation of Rehabilitation Management Plans would be staged, with each plan covering a defined area or domain for rehabilitation.

It is estimated that the Project would involve approximately 37 ha of vegetation clearance activities for the temporary surface disturbance areas. As described in Section 5.8.3, surface disturbance works would be sited, where practicable, to minimise the amount of disturbance and vegetation clearance required (e.g. by locating infrastructure in previously disturbed areas and avoiding tree removal). ICHPL would carry out rehabilitation progressively and as soon as practicable following the disturbance.

Erosion and sediment control strategies for the Project would be documented in relevant environmental management plans. Temporary erosion and sediment controls (e.g. silt fences and sediment control structures) would be installed prior to the commencement of surface disturbance activities. Erosion and sediment control measures would be designed in accordance with applicable erosion and sediment control principles and guidelines (e.g. *Managing Urban Stormwater: Soils and Construction* [Landcom, 2004]). Erosion and sediment controls would remain in place until such time as ground disturbed by the works has been stabilised.

It is anticipated that some disturbance areas would be of a size that revegetation of the disturbed area would occur naturally from adjacent native vegetation. In other disturbance areas (e.g. temporary access tracks), measures may be implemented to encourage natural regeneration (e.g. placing stockpiled vegetative material over cleared areas).

Active revegetation of native vegetation (e.g. planting and/or direct seeding) would be implemented in the event natural regeneration is not considered to be progressing satisfactorily. The selection of species for active planting and/or direct seeding would be determined in consideration of the site characteristics (e.g. slope, elevation and soil) and vegetation communities at, or in the vicinity of, the disturbance area. The active revegetation programme would utilise endemic plant species. Specifically, any active revegetation in the SCA Special Areas or Dharawal State Conservation Area would utilise seed collected from that particular Special/Conservation Area. Active revegetation activities would include the seeding and/or planting of upper, mid and lower storey native species.

Monitoring of rehabilitated areas would be conducted to assess the performance of the rehabilitation measures and to identify the requirement for any maintenance and/or contingency measures (e.g. weed control, erosion and sediment control, or active revegetation measures).

6.4 MINE SUBSIDENCE IMPACTS

6.4.1 Streams

In relation to stream remediation, Recommendation 34 of the Metropolitan PAC Report states (page 147):

> ***Recommendation 34***
>
> *The Panel recommends that remediation be required where subsidence impacts cause diversion of flows or drainage of pools with the objective of restoring flows and pool holding capacity to pre-mining levels as quickly as possible. The Panel notes that more than one remedial effort may be required at an individual feature (eg a rock bar) given that the total impacts are expected to be associated with successive longwalls. The Panel recommends that approval conditions should require close monitoring of impacts from all longwalls likely to affect such key features.*

ICHPL has successfully remediated a series of impacted pools on the Georges River (BHP Billiton, 2004a). Stream remediation measures have also been implemented at the Metropolitan Colliery on Waratah Rivulet (HCPL, 2008). A summary of these methods from Appendix C and their possible application to different situations is provided in Table 6-1. The full range of available techniques would be considered in the design of future stream remediation programmes.

As described in Section 2.5.2, a 200 mm closure threshold has been applied to the longwall layouts to avoid significant fracturing of rockbars on O'Hares Creek, Stokes Creek (reaches 1 and 2), Cataract River, Lizard Creek, Georges River reach 2 and the Nepean River reach 1. As a result, it is not anticipated that stream remediation measures would be required for these sections of streams, other than that required for contingency measures.

Achievement of the 200 mm criteria on the abovementioned stream reaches would also result in a significant reduction of subsidence effects on sections of stream between each rockbar feature (Appendix A). Notwithstanding, stream remediation measures (e.g. grouting) on rivers and stream reaches of third order and above would be conducted where subsidence results in the draining of pools in stream sections between controlling rockbars, where the remediation measures are considered technically feasible.

Further, the longwall layout would be designed not to directly undermine the Nepean River (reaches 2 and 3) and the headwater reaches of the Georges River (i.e. Georges River reach 1) and Woronora River. This would result in a reduction in potential subsidence effects (Appendix A). Notwithstanding, it is anticipated that some stream remediation works would likely be required (particularly the Georges and Woronora Rivers).

Where fracturing of controlling rockbars results in surface flow diversion and draining of pools, ICHPL proposes to remediate the controlling rockbars (and associated pools) on rivers and stream reaches of third order and above. The rockbars on these stream reaches are shown on the stream mapping provided in Appendix P. In addition, where subsidence results in surface flow diversion and draining of pools in stream sections between controlling rockbars, ICHPL proposes to implement stream remediation measures on rivers and stream reaches of third order and above where the stream features are such that remediation measures are technically feasible.

Table 6-1
Summary of Proposed Stream Remediation Techniques

Restoration Technique	Description	Applications and Limitations
Hand grouting	Sealing of cracks exposed on the surface using hand applicators. A variety of sealants can be used including sealants that can be applied under water.	Limited to surface cracks which can be accessed using hand held application equipment.
Shallow pattern grouting	Drilling shallow holes using small hand held drilling equipment and low pressure injection of a grout using a portable pump. Grouts used successfully on the Georges River incorporated a cement mix that can be used with or without additives (e.g. bentonite).	Used to seal shallow fractures in rockbars and pools. Applicable to sensitive areas where access for larger equipment is problematic. Better results can be obtained if the target fractures are dewatered.
Deep pattern or curtain grouting	Drilling deeper holes using traditional air and or reverse circulation drilling rigs. Higher pressure grouting techniques can also be used. Grouts used successfully on the Georges River incorporated a cement-bentonite mix.	Used to seal fracture networks at greater depths. Can seal larger and deeper fractures. Larger equipment may necessitate constructing access tracks. Less suitable for remote or difficult access sites.
Deep angle hole cement grouting	Remote directional drilling techniques can be used to access otherwise inaccessible sites. The same grouting methods as deep pattern/curtain grouting outlined above can be used.	Specialised technique which can be used in situations where drill access is available close to target site.
Polyurethane grouting	Use of expanding polyurethane grouts to seal fracture networks. Polyurethane, which is a rapid setting grout that sets under water, is pumped into closely spaced drill holes (pattern drilling) and fractures filled systematically from "bottom up".	Technique used successfully on Waratah Rivulet by HCPL. Can be used under water and under low flow conditions. Can be used to fill large aperture fractures in stages.

Source: BHPIC (2006); HCPL (2008).

As described in Appendices C and P, Project surface water monitoring would include:

- flow monitoring to contribute to the quantitative understanding of the pre-mine catchment via the use of baseline models;
- specific monitoring aimed at quantifying local flow diversion phenomena; and
- pool level monitoring to contribute to the quantitative understanding of the pre-mine pool water balance dynamics via the use of baseline models.

The above monitoring would be used to identify the need and subsequent success of stream remediation works.

Stream Remediation Success Criteria

Based on the objectives of stream remediation stated in Recommendation 34 of the Metropolitan PAC Report (stated above), stream remediation success criteria proposed to be adopted for the Project is as follows:

> *Surface flow and pool holding capacity of the remediated pool have been restored to pre-mining levels.*

As indicated in Recommendation 34, the Panel notes that more than one remedial effort may be required at an individual feature (e.g. a rockbar) given that the total impacts are expected to be associated with successive longwalls.

A programme would be developed to monitor the performance of the stream remediation works. Examples of the type of monitoring parameters relevant to this programme include:

- Quantification of local flow diversion.
- Monitoring and reporting of remediation methods.
- Effectiveness of environmental controls implemented during remediation works.
- Permeability testing.
- Water quality monitoring.
- Pool water level monitoring.
- Other environmental monitoring (e.g. aquatic ecosystem monitoring as described in Section 5.7.3).

6.4.2 Swamps

ICHPL proposes to implement rehabilitation measures, where necessary, to maintain the physical state and function of a swamp that experiences subsidence impacts.

Examples of potential rehabilitation measures include knick point control, water spreading, sealing of bedrock fractures and injection grouting. An overview of these measures is provided below. Potential rehabilitation measures for specific swamps would be provided in the Upland Swamp RMPs to be prepared and included in Extraction Plans.

Knick Point Control

Tilting of sufficient magnitude can re-concentrate runoff leading to scour and erosion or alter water distribution in parts of a swamp. Coir log dams can be installed at knick points, such as those shown in Plate 6-1. The square coir logs used for the construction of these small dams were developed specifically for swamp rehabilitation and have been successfully used during a number of swamp rehabilitation programmes of recent years in the Blue Mountains and Snowy Mountains (Good *et al*., unpublished).

Plate 6-1 - Square Coir Logs for Knick Point Control

Source: Good *et al.* (unpublished).

A trench is cut into the swamp soils such that the first layer of coir logs sits on the underlying substrate or the top of the first coir log is at ground level. The coir logs are held in place by wooden stakes and bound together with wire. The coir log dam slows water flows, allowing siltation behind the log dam (Good *et al*., unpublished). The small coir log dams are constructed at intervals down the erosion channel. Where increased filtering of flows is required, the coir logs can be wrapped in jute fibre matting as shown in Plate 6-2.

Plate 6-2 - Small Coir Log Dams Constructed at Intervals along an Incised Swamp with Jute Wrapping

Source: Good *et al*. (unpublished).

The main objective of siting erosion control structures at these locations is to maintain the saturated water level in the soil profile by reversing the hydraulic head to enable water to permeate back into the profile of the swamp (Good *et al*., unpublished). A secondary benefit is the capture of sediment to restore the incised channel to the level of the surrounding intact soil layer and to provide a physical barrier to the head-ward erosion mechanism commonly seen in deep sediment profiles.

Water Spreading

The maintenance of the swamp moisture regime can also be enhanced by additional water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across the contour such that water flow builds up behind them then slowly seeps through the water spreaders (Good *et al*., unpublished). The water spreaders can be positioned as required within shallow trenches within a swamp (Plate 6-3).

Plate 6-3 - Round Coir Logs Installed to Spread Water

Source: Good *et al*. (unpublished).

Erosion control and water spreading involves soft-engineering materials that would contribute to and function as part of the swamp system but would eventually degrade (totally biodegradable) and become integrated into the soil/organic matter complex of the swamps (Good *et al*., unpublished).

Sealing of Bedrock Fractures

It has been observed that many swamps terminate in rocky outcrops or exposed rock platforms. Where bedrock controlled features situated within or on the margins of swamps are impacted from subsidence and where there is limited ability for fractures to infill naturally, surface cracks have the potential to be sealed through the use of grouting products. A number of grouting products are available, including cement with or without various additives. Generally, small quantities would be expected to be required, allowing the product to be mixed on-site and placed by hand (Appendix O).

Injection Grouting

Injection grouting involves the delivery of grout through holes drilled into the controlling rockbar of a swamp. A variety of grouts and filler materials can be injected to fill the voids in the fractured strata intercepted by the drill holes. The intention of this grouting is to achieve a low permeability 'layer' approximately 1 to 2 m thick below the depth of any controlling rockbar. Extension rods can be used to increase the depth of the drill holes to target any deeper fracturing which is considered to be a conduit for subsidence induced sub-surface flow. Where alluvials overlie sandstone, grouts may be injected through grout rods to seal voids in or under the soil or peat material (Appendix O).

6.4.3 Other Natural Surface Features

In addition to the stream and swamp rehabilitation measures described above, rehabilitation may be undertaken to remediate mine subsidence impacts (e.g. surface cracking or erosion) on other natural surface features, as described below.

Regular visual monitoring would be conducted to identify any areas subject to excessive erosion and sedimentation as a result of Project subsidence effects. Specific mitigation measures that may be employed include:

- filling of cracks and minor erosion holes, where practicable;
- installation of sediment fences downslope of subsidence-induced erosion areas;
- stabilisation of erosion areas using rock or other appropriate materials;
- stabilisation of banks subject to soil slumping; and
- revegetation using brush matting, seeding or tubestock.

As described in Section 5.4.2, mine subsidence has the potential to cause surface cracking, including surface tension cracking near the tops of slopes. If tension cracks are left untreated, there is potential for soil erosion to increase. Where significant cracks are detected and the potential for soil erosion (or other environmental consequences) is considered to be significant, they would be repaired/filled as soon as practicable.

Potential rehabilitation measures for impacts on vegetation include the implementation of weed control measures (e.g. mechanical removal or the application of approved herbicides) and the planting of endemic plant species. Any active planting would utilise flora species characteristic of the particular vegetation community in that area and would utilise seed collected from the local area.

6.5 LEASE RELINQUISHMENT

Upon cessation of mining operations, it would be expected that tenure of the mining and coal leases would be maintained by ICHPL until such time as lease relinquishment criteria were satisfied. These criteria would be formulated and prescribed in consultation with relevant authorities and stakeholders.

It is anticipated that mine relinquishment criteria would include, but not necessarily be limited to the following:

- removal of infrastructure, where appropriate and required;
- landform stability and public safety;
- maintenance of downstream water quality;
- establishment of self-sustaining vegetation in previously cleared areas; and
- fulfilment of mining and coal lease and other statutory approval conditions.

Lease relinquishment criteria would be detailed in Mine Closure Plans.