APPENDIX D-1 GOLDER ASSOCIATES BEDDING SAND DESKTOP REPORT

May 2009

CONNORS RIVER DAM TO MORANBAH PIPELINE

Bedding Sand Desktop Review

Submitted to:
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REPORT

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1.0 INTRODUCTION

In conjunction with the development of the Connors River Dam, SunWater have commenced development of a pipeline to supply water from the dam to Moranbah. The Connors River Dam (CRD) to Moranbah pipeline is approximately 145 km in length and is assumed to follow the "northern" route proposed by SunWater and shown in drawings provided by G Dryden (SunWater) on 26 March 2009, refer Figure 1. We understand that the final pipeline alignment may vary from that currently indicated.

Figure 1: Proposed Northern Pipeline Route

As part of the project development SunWater has commissioned Golder to undertake a desktop review of sources of bedding sand for the pipeline, including a two day field inspection of potential borrow areas. The objective of the desktop review was to provide a report describing:

- Methodology of investigation;
- Observations from the field inspection;
- Recommendations regarding prospective target areas for future intrusive investigations, including colour photographs of prospective deposits; and
- Advice regarding the likely permits that will be required at each of the target areas to perform intrusive investigations.

In addition, Golder was requested to provide preliminary advice on the likely permitting requirements to extract sand from prospective river sources.

1.1 Bedding Sand Requirements

We understand that the pipe is likely to be 1.2 m in diameter and will have an invert level at a maximum depth of approximately 3.5 m below surface. We understand that SunWater require approximately 340,000 m^3 (563,000 t) of bedding sand for the CRD to Moranbah water supply pipeline. SunWater has developed a specification for granular backfill around pipes that varies from the Australian Standard (AS/NZC 3725:2007) for use on previous pipeline projects. A copy of this has been provided to Golder and we understand that the following properties are typically required by SunWater for bedding sand:

- Naturally occurring gravelly sand or other granular material meeting the grading specified in Table 1
- The grading curve shall be smooth
- Free from cohesive material and free draining

- Fine materials (passing 0.075 mm sieve) shall be non-plastic
- No angular or sharp particles such as quarry crusher fines shall be used.

Table 1: Bedding Sand Grading Envelope

AS Metric Sieve (mm)	Percentage Passing
19	100
4.75	90 – 100
2.36	60 – 100
1.18	30 – 97
0.425	3 – 50
0.150	0 – 5
0.075	0 – 3

2.0 METHODOLOGY

The desktop review of potential bedding sands for the CRD to Moranbah pipeline involved the following activities:

- Review of the following documents:
  - "Workings of Construction Materials in the Mackay Area", W F Willmott & B J Neville GSQ, Qld Gov't, Mining Journal May 1979 209-221
  - "Workings of Construction Materials in the Northern Bowen Basin" (Collinsville-Nebo-Moranbah Areas), D L Trezise, P F Graham, CSQ, Qld Gov't, Mining Journal Sept. 1981 435-448.
- Review of the following maps:
  - Geological Series: 1:100 000 Scale Nebo, Carmila and Connors Range Map Sheets; 1:250 000 Scale Mackay, Mount Coolon, and St Lawrence Map Sheets
  - Topographic: 1:250 000 Supplied by Australian Government (Geoscience)
- Review of aerial images from Google Maps & Google Earth (accessed April 2009)
- Two day field inspection
- Investigation of existing commercial sources
- Investigation of permitting requirements for investigation and sand extraction.

3.0 DESKTOP REVIEW

In the Mackay area the major sources of sand used for fine concrete aggregate, road pavements, fill and bedding sand are deposits of sand and sandy gravel in the beds of the Pioneer River and its tributary, Cattle Creek. Plane Creek, located 5 km southwest of Sarina, has been identified as a potential future source with a large deposit of coarse grained sand, fine to coarse gravel and abundant cobbles and boulders available. This deposit was estimated to be 1 to 2 m thick and extending over an area of 1 km by 50 m. However,

some or all of the resource may have been extracted since the publication of the Journal in 1979 as extraction applications had been lodged at that time.

Sand extraction in the Nebo area has reportedly been undertaken in Nebo and Denison Creek by the then Nebo Shire Council and the Main Roads Department. Alluvial sands and gravel, consisting of medium to coarse grained, angular quartz sand with gravel to 50 mm of rounded jasper and volcanic and indurated siltstone pebbles, were excavated from shallow pits in Nebo creek, west of Nebo. Extraction of medium to coarse grained sand from a small sand pit in the Denison creek has also been undertaken. The sand reportedly contains angular quartz grains and minor feldspar and granite fragments with very little gravel. The sand reserves in both the Nebo and Denison Creeks are believed to be partially replenished during flooding.

The 1981 paper also identifies a number of potential sand sources around Nebo:

- Denison Creek, upstream of the Peak Downs Highway – very large deposits of medium to coarse sand and some granitic gravel
- Funnel Creek – large sand reserves
- Sandy Creek – large sand reserves
- Nebo Creek, west and north of Nebo – moderate reserves of medium to coarse grained quartz sand and gravel.

Sand supply to the Moranbah region has historically come from the Isaac River. A number of pits have been worked in the bed of the Isaac River at Moranbah and at Goonyella. The pits are worked using endloaders to depths of between 2 and 3 m. The material extracted near Moranbah is typically medium to coarse grained quartz sand, subangular to subrounded, with gravel to 20 mm and some scattered ironstone. The sand extracted near Goonyella is typically coarse quartz sand, well rounded, and silty with minor coarse gravel. A particle size distribution has been provided for the Isaac River sand extracted near Goonyella and is shown comparative to the SunWater grading envelope below.

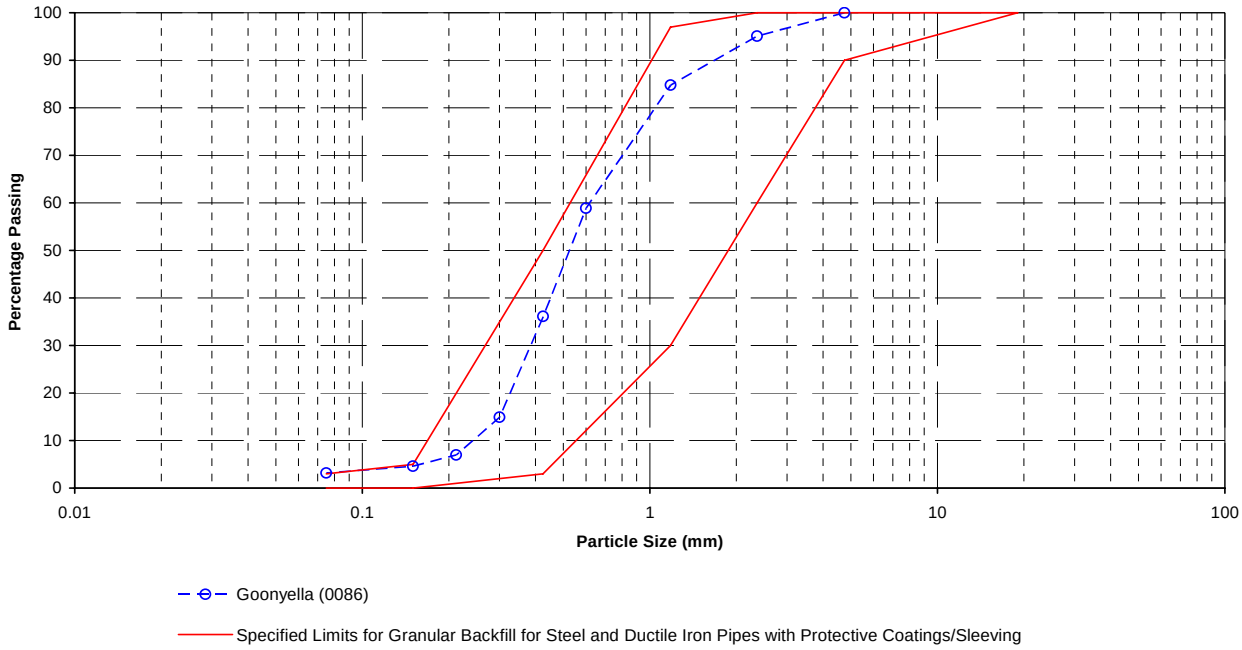

Figure 2: Isaac River Sand Grading Curve, Goonyella

The bed of the Isaac River is assessed to contain very large reserves of medium to coarse quartz sand suitable for use as bedding sand.

4.0 FIELD INSPECTION

The two day field inspection was undertaken on 26 and 27 March 2009 by Amanda Barrett and David James of Golder Associates in the company of Greg Dryden of SunWater. From the township of Nebo the general pipeline route was followed along formed roads, access tracks and on foot. A hand held GPS was used to track the route followed during the inspection.

The route followed on Day 1 is shown on Figure 3 and included stops at four locations (as marked 1 to 4) where visual inspections of the sites were made.

Figure 3: Day 1 Route

Stops were made at the following locations during Day 1 of the site visit:

1) Isaac River at Peak Downs Highway;
2) Isaac River at proposed pipeline crossing;
3) Moranbah Terminal Storage Facility;
4) Funnel Creek channel, south of Denison Creek junction (western side)

The route followed on Day 2 is shown on Figure 4 and included stops at ten locations (as marked 5 to 14) where visual inspections of the sites were made.

Figure 4: Day 2 Route

Stops were made at the following locations during Day 2 of the site visit:

5) Boothill Creek at Marlborough Sarina Rd
6) The Junction of Boothill Creek and Funnel Creek
7) Boothill Creek at the Windmill
8) Funnel Creek channel, south of Denison Creek junction (eastern side)
9) Nebo Creek/Cooper Creek
10) Bee Creek
11) Harrybrandt Creek at Fitzroy Development Road
12) Harrybrandt Creek tributary at Mac Centre
13) North Creek tributary at Daunia Road
14) North Creek

5.0 POTENTIAL COMMERCIAL SOURCES

The search for potential commercial bedding sand sources commenced with an on line search of (electronic) Yellow Pages. The following business types were checked within the Isaac Regional Council, Queensland location and the surrounding areas:

- Sand, Soil & Gravel—W'salers & Producers
- Sand, Soil & Gravel—Retail
- Quarries with Sand (subsequently removed as search option in Yellow)

These searches produced limited commercial operations close to the proposed pipeline route. Most operations were close to Rockhampton and Mackay with one operation in each of Proserpine, Emerald and Moura. Two retail operations were listed in Moranbah.

5.1 Moranbah Region Suppliers

5.1.1 Mal's Plant Hire

The first Moranbah operation contacted referred our inquiry for bedding sand to CQE Hire. CQE Hire was not listed on any of the search results. CQE Hire was no longer trading and had sold the sand extraction business to Mal's Plant Hire. Mal's Plant Hire was not listed in any search results and could not be found in on line searches using Yellow or White Pages.

Mal's Plant Hire indicated that they had the only commercial sand extraction operations from the Isaac River near Moranbah. Their operations were north of the railway bridge which is to the north of the Moranbah township. These extraction operations had reached the allocated limit in October 2008 and extraction cannot commence again until June 2009. Application had been or is being made by Mal's Plant Hire for a further extraction allocation however no response had yet been received from the regulator. The size of the allocation may limit the amount that can be commercially available for the pipeline as the current extraction limit does not meet the other local commercial requirements.

Mal's Plant Hire provided a particle size distribution of the extracted and screened sand from late February 2008 when the operations were still worked by CQE Hire. These results are discussed below. Mal's Plant Hire indicated that they generally win the sands from the bed of the Isaac River, transport it to the bank, screen it to remove oversize particles and large sticks and stockpile it. The sand is not washed as part of their processing. Historical images from Google Earth of the extraction process from the Isaac River close to Moranbah are presented below.

Figure 5: 30 May 2005 Google Earth Image of sand extraction operations from Isaac River bend near Grosvenor Downs

Figure 6: 30 May 2005 Google Earth image of sand extraction operations from Isaac River bend at Moranbah near proposed pipeline crossing location

These images indicate that the sand may have been won from the bed materials by excavation or dozing and stockpiling on the adjoining bed materials. These sandy bed materials probably contain water at shallow depths. These actions probably wash the sand of any fines or thin fines-rich layers observed during the field inspection. Thin zones of fines were observed on the surface of the Isaac River bend at Moranbah near the proposed pipeline crossing location. These zones may have been associated with drying muddy puddles. These fines are probably dispersive. The zones of fines are probably removed during the extraction operations by mixing (stirred up) with water in the bed and then draining out of the stockpiles back into the bed sands.

5.1.2 Quarrico

Mal's Plant Hire further indicated that they were currently transporting raw sand for Quarrico (Grosvenor Quarry, Moranbah) from Theresa Creek south of Clermont. This sand was being screened at the Grosvenor Quarry between Moranbah airport and town. Quarrico was not listed in the results of any of the above discussed on line Yellow searches or a search for "Quarries" located in the Isaac Regional Council area. Quarrico have a web site and a printout of the information from this site is appended. Quarrico was contacted and asked for a typical particle size distribution for the screened sand (or sands) they sell. As requested this telephone enquiry was confirmed by email. To date no response has been received. Quarrico did indicate that they had submitted a sand extraction allocation application for a site in the Winchester area. Winchester is south-west of Moranbah along the Peak Downs Highway towards Clermont.

5.1.3 Moranbah South Quarry

During the field inspection a notice board for Moranbah South Quarry was seen on the Peak Downs Highway to the east of the Moranbah Access Road. This quarry is operated by MCG Civil Pty Ltd. MCG Civil were contacted and indicated that the Moranbah South Quarry is a hard rock quarry and no sand is supplied from this operation. The closest product to sand produced was crusher dust.

5.2 Nebo Region Suppliers

Commercial sand extraction operation may operate from Nebo Creek. The Isaac Regional Council depot in Nebo and the Cemex (Readymix) concrete plant in Nebo were contacted regarding local sand suppliers. The Council indicated that they thought they sourced sand from Mackay through "Walmsley". On line searches using Google, Yellow and White Pages failed to identify any Walmsley associated with sand supplier activities in or around Mackay or Nebo or residential entries for Nebo and surrounds.

5.2.1 Cemex Nebo

Cemex Nebo is supplied by Cemex's Sarina District Quarries operations. Three hard rock quarries and two sand mines (extraction leases) were acquired from John and Pat Croyden, trading as JT & PA Croyden Pty Ltd (Croyden), and are now operated by Cemex as the Sarina District Quarries. Two sands can be supplied by the Sarina District Quarries. These sands are:

- clean fine sand which is sourced from an extraction lease on Alligator Creek approximately 40 km north of Rockhampton
- coarse sand sourced from the "DPI Lease" at Mia Mia on the upper reaches of the Pioneer River.

Both these extraction leases have limited annual extraction allocations. These sands are generally required for concrete production for the Cemex operations in the area. Cemex did not consider it appropriate to provide typical particle size distributions for these sands because they were not in a position to supply.

Cemex indicated that they had approached the Nebo Creek sand supplier (would not name the supplier) to supply fine sand for their Nebo concrete plant with a negative response. The Nebo Creek sand supplier indicated that their annual extraction limit was just enough to supply current demands and no new business could be supplied.

Cemex also indicated that they did not think that all the current extraction allocations in the area could supply a quantity of bedding sand in excess of 340,000 m³.

The consensus of the commercial sand suppliers contacted is that the current extraction allocations for local river/creek bed sand is slightly lower than current demand and an additional large bedding sand demand would require significant extra extraction allocations.

5.3 Isaac River Sand

As discussed above Mal's Plant Hire provided a particle size distribution of the extracted and screened sand from late February 2008 when the operations were still worked by CQE Hire. The results of this particle size distribution are appended and shown relative to the SunWater grading limits below. The sample was taken by Bowler Geotechnical and had the Sample Reference Nº of M08/0183.

This particle size distribution indicated that the sand was clean and medium to coarse grained which generally agreed with the field inspection observations of bed materials further downstream in the Isaac River.

This particle size distribution generally falls within the SunWater specified limits (grading envelope) for granular backfill for steel and ductile iron pipes with protective coatings/sleeving. This material is on the fine side of the envelope and river/creek bed sands consisting of finer particles (i.e. fine to medium grained) are unlikely to meet the specified limits.

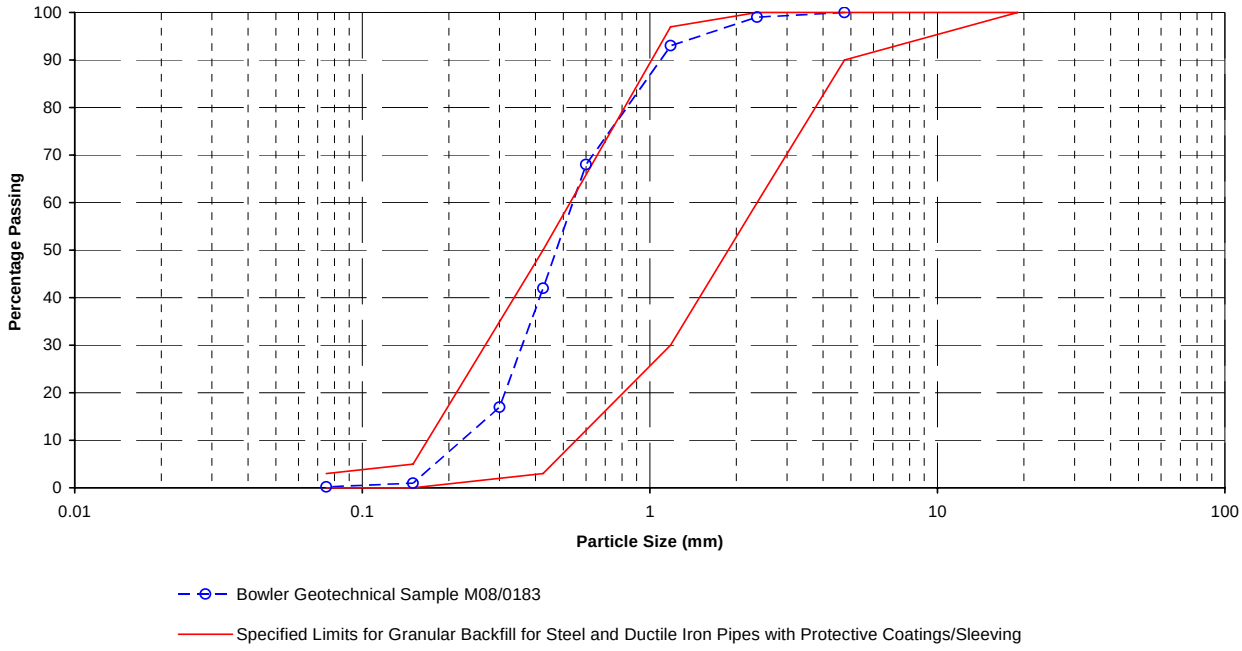

Figure 7: Isaac River Sand Grading Curve Upstream of Railway Bridge

In comparison to the grading of sand from the Isaac River near Goonyella (Figure 2), this sand is finer grained and has a lower percentage of fines. As Goonyella is upstream of Moranbah it might be expected that the sand extracted there would be coarser. The lower fines content observed in the Bowler tested sample is consistent with the extraction methods applied and subsequent natural "washing" of dispersive fines.

6.0 POTENTIAL SAND EXTRACTION LOCATIONS

A discussion of the potential sand extraction locations in the vicinity of the proposed CRD to Moranbah pipeline route is provided in this section. For each potential resource the following items have been considered and discussed:

- Location;

- site access;
- description of resource;
- geological source;
- estimated resource extent; and
- any other comments.

6.1 Isaac River

Location

The proposed pipeline route crosses the Isaac River at approximately 135 km from the proposed Connors River Dam or 11 km from the Moranbah terminal. The Isaac River generally flows from the north-west towards the south-east in the vicinity of the proposed crossing point which is to the east of Moranbah. Five kilometres south-east of the proposed crossing point the Peak Downs Highway crosses the Isaac River. The Isaac River and its tributaries drain the western side of the Burton and Kerlong Ranges to the north-east of Moranbah.

Site Access

The proposed pipeline crossing is located close to and downstream of one of the gazetted roads to the Moranbah pastoral property. This roadway includes a bed-level earth and rock fill and pipe type causeway crossing of the Isaac River. This causeway probably suffers damage each wet season associated with flood flows in the Isaac River. A number of gazetted roads access the banks and cross the Isaac River associated with the Grosvenor Downs, Moranbah and Wotonga pastoral properties. These roadways are generally gravel roads and tracks. In the vicinity the Isaac River is also crossed by the Peak Downs Highway, the Wotonga Blair Athol Branch Railway and power line easements. The eastern bank of the Isaac River north of the Peak Downs Highway is accessed by a Grosvenor Downs pastoral property gated farm track. Study of Google Earth indicates that a number of similar tracks and river access points may exist in the vicinity.

Description of resource

Visual inspection of the river sand in the Isaac River was undertaken at the Peak Downs Highway and at the proposed pipeline crossing point. The alluvial sand was observed to be predominantly medium to coarse grained, sub-rounded and predominantly composed of quartz and feldspar. Traces of fine to medium gravel were observed in some areas and isolated lenses with volcanic rock cobbles were also seen. The fines content of the sand was noted to be very low, however at the pipeline crossing dried silt patches were observed on the surface. The sand grading and presence of coarser materials varied in relation to the depositional location, centre or edge of channel, outer or inner edge of bends, etc. Organic material was present at the ground surface but in limited quantities due to the relatively recent flood event in the Isaac River. Groundwater was observed close to the surface of the river bed (up to 0.3 m depth).

8A – Downstream Bed

8B – Upstream Bed

8C – Typical Bed Material

8D – Upstream Point Bar

8E – Upstream Point Bar Bed Material

F – Upstream Point Bar Bank Material

Figure 8: Isaac River Adjacent Peak Downs Highway

A – Downstream Bed

B – Right-Hand Side Upstream Bed

C – Left-Hand Side Bed from Downstream

D – Typical Dried Bed Surface Silt Patch

Figure 9: Isaac River Around Proposed Pipe Crossing Location

Geological source
The geological formations present upstream on the Isaac River include the Suttar Formation, Clematis Sandstone and Rewan Group. These are predominantly quartz or lithic sandstones with conglomerate and mudstone. Smaller creeks feeding into the Isaac River also typically run off sandstone and siltstone units and infrequently run off basalt.

Any Other Comments
Vast reserves of predominantly medium to coarse quartz sand are present in the Isaac River channel. Sand extraction will therefore be limited based on the Department of Natural Resources and Water extraction limits. The gazetted bed-level causeway type crossings of the Isaac River will probably have to be maintained, limiting the extent of any extraction operations.

6.2 North Creek

Location
The proposed pipeline route crosses North Creek at approximately 101.5 km from the proposed Connors River Dam or 44.5 km from the Moranbah terminal. North Creek generally flows from the north north-west towards the south south-east in the vicinity of the proposed crossing point which is adjacent to the Peak Downs Highway to the east of Annandale and south-west of the southern end of the Kerlong Range. North Creek and its tributaries drain the western side of the southern end of the Kerlong Range to the north and north-east of Annandale.

Site Access
North Creek can be accessed to the south of the Peak Downs Highway via the Daunia Road and power line easements.

Description of resource
At the North Creek crossing of the Peak Downs Highway bridge construction appears to have reduced the flow rates of the river resulting in the formation of a water hole. Sand was observed in the river channel upstream of the bridge but we were unable to access that location and therefore a visual assessment of the sand was not possible. The banks of the river comprised silty fine grained sand and were heavily vegetated with grasses.

10A – Upstream Peak Downs Highway Bed

10B - Downstream Tributary Adjacent Daunia Road Bed

10C – Downstream Tributary Adjacent Daunia Road Point Bar

Figure 10: North Creek Adjacent Peak Downs Highway

Geological source

Along the alignment of North Creek the geological units intersected are the same as those upstream along the Isaac River, Suttar Formation, Clematis Sandstone and Rewan Group. In addition, micaceous lithic sandstone and siltstone of the Moolayember Formation are also present along North Creek.

Estimated Resource Extent

The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 59 250 m² of the bed of North Creek to the south of the Peak Downs Highway and west of Daunia Road may yield sandy materials that could be utilised as bedding sand depending on grading.

Any other comments

Although no visual inspection of the sand in North Creek was possible, based on the upstream geological formations it would be expected that the sand would be similar to that seen in the Isaac River.

6.3 Harrybrandt Creek

Location

Harrybrandt Creek and its tributaries occur adjacent to and south of the proposed pipeline route and the Peak Downs Highway from approximately 70 km to 94 km from the proposed Connors River Dam or 52 km to 76 km from the Moranbah terminal. Harrybrandt Creek generally flows from the west south-west towards the east south-east in the vicinity of the proposed pipeline route to the south of Coppabella which is adjacent to the Peak Downs Highway and to the west of the northern end of the Fitzroy Development Road. North Creek and its tributaries drain the eastern side of the southern end of the Kerlong Range adjacent to Coppabella and Mount Marion and the Flora Range to the east south-east of Coppabella.

Site Access

Study of Google Earth indicates that Harrybrandt Creek should be able to be accessed at a number of points via farm tracks which cross the watercourse.

Description of resource

Sand deposited in a tributary of the Harrybrandt Creek (Figure 4, Location 12) adjacent to the Peak Downs Highway was inspected. The sand comprised predominantly fine to medium grained, sub-rounded quartz grains with traces of fine rounded gravel and up to approximately 5% fines content. A significant build-up of sand had occurred around a number of low lying culverts providing road access to an accommodation centre. At the edge of the sand deposit increased fines contamination was observed from sediment laden storm water run-off.

11A – Downstream Peak Downs Highway Bed

11B – Downstream Side Mac Centre Access Culvert Bed

11C – Downstream Mac Centre Access Bed

Figure 11: Tributary Harrybrandt Creek Adjacent Peak Downs Highway at Coppabella

Geological source

Four main geological units are present in the vicinity of Harrybrandt Creek including the Blackwater Group, the Blenheim Formation, and part of the Back Creek Group to the south, and the Clematis Sandstone and Rewan Group to the north. Alluvial sediments derived from the weathering of these typically quartzose or lithic sandstone units flow into Harrybrandt Creek from its tributaries including Thirty Mile Creek and Pear Gully to the north and Dingo and Oaky Creeks to the south.

Estimated Resource Extent

The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 410 100 m² of the bed of Harrybrandt Creek to the south of the Peak Downs Highway and west of the northern end of the Fitzroy Development Road may yield sandy materials that could be utilised as bedding sand depending on grading.

Any Other Comments

The water in Harrybrandt Creek and its tributaries appeared to be discoloured downstream of the Coppabella mining operations. The discolouration is likely caused by fine sediment accumulating in the creek water during high flow events. It would be expected that this fine sediment would be deposited in the river channel in times of low flow and may result in material with a higher than allowed fines content.

If representative, the fine to medium sand observed in the tributary of the Harrybrandt Creek is likely to be too fine to meet SunWaters grading requirements without addition of coarse sand to gravel particles.

6.4 Bee Creek

Location

The proposed pipeline route crosses Bee Creek at approximately 69 km from the proposed Connors River Dam or 77 km from the Moranbah terminal. Bee Creek generally flows from the north-west towards the south-east in the vicinity of the proposed crossing point which is along the BMA easement near the Peak Downs Highway to the south of Mindi.

Site Access

Study of Google Earth indicates that Bee Creek should be able to be accessed at a number of points via the BMA easement, farm tracks which cross the watercourse and power line easements or property boundary fence lines.

Description of resource

The material deposited in the bed of Bee Creek at the Peak Downs Highway crossing was observed to comprise quartz and lithic gravelly sand. The sand was predominantly coarse to medium grained; the gravel was fine grained and both were typically sub-angular to sub-rounded. Groundwater was observed at approximately 0.2 m below the bed level.

12A – Upstream Bed

12B – Downstream Bed

Figure 12: Bee Creek Adjacent Peak Downs Highway

Geological source

Geological formations along Bee Creek include the typical sandstone units of the Blenheim Formation, Gebbie Formation, Blackwater Group, Rewan Group and Upper Bowen Coal Measures. In addition, the Gatthardt Granodiorite (a biotite-hornblende granodiorite), granite, Tertiary basalt, volcanics and diorite are present.

Harrybrandt Creek flows into Bee Creek north of the north-west corner of Dipperu National Park.

Estimated Resource Extent

The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 133 200 m² of the bed of Bee Creek to the south of the Peak Downs Highway and adjacent to the BMA easement may yield sandy materials that could be utilised as bedding sand depending on grading.

6.5 Nebo Creek (Cooper Creek)

Location

The proposed pipeline route crosses Nebo Creek at approximately 51 km from the proposed Connors River Dam or 95 km from the Moranbah terminal. Nebo Creek generally flows from the north-west towards the south south-east in the vicinity of the proposed crossing point which is adjacent to the Braeside bore field to the south south-east of Nebo.

Site Access

Study of Google Earth indicates that Nebo Creek may be difficult to access with a single power line easement or property boundary fence line in the vicinity. However Nebo Creek may have old filled channels. One of these filled channels should be able to be accessed at a number of points via the well maintained Cockenzie Road, the BMA easement, poorly maintained farm tracks and power line easements or property boundary fence lines.

Description of resource

Water up to 0.7 m deep was flowing in Nebo Creek at the Peak Downs Highway bridge crossing, just south of the junction with Cooper Creek, at the time of the site visit. The creek bed appeared to be comprised of a mixture of coarse gravel to cobbles on the right bank and downstream and sand with fines on the left bank. Exposed sediments on the vehicle access track near the river are fine to coarse sand with some fines and some sub-rounded lithic (volcanic) cobbles at surface.

13A – Downstream Right Bank

13B – Downstream Left Bank

13C – Mid Left Bank "Sand" Bank Material

13D – Lower Left Bank Bed Material

13E – Mid Left Bank Bed Material

13F – Upper Left Bank Bed Material

Figure 13: Nebo Creek Adjacent Peak Downs Highway

Geological source

Cooper Creek flows into Nebo Creek just north of the project area, bringing with it varied sediments from the geological units it flows through. Along its length Cooper Creek passes sedimentary formations including the Bowen Coal Measures and Back Creek Group and volcanics including the Lizzie Creek Formation (andesite flows, sills, crystal and lithic tuffs and agglomerate), Lower Bowen Volcanics (granite, basalt, diorite and acid and intermediate volcanic flows).

Nebo Creek itself passes through predominantly volcanic rocks including those of the Lower Bowen Volcanics, the Urannah Complex (granite, diorite, granodiorite with abundant dykes) and Tertiary basalt and volcanic flows and pyroclastics.

Estimated Resource Extent

Study of Google Earth (refer Appendix C) indicates that approximately 997 100 m² of the filled old Nebo Creek channel to the south of the Peak Downs Highway and adjacent to Cockenzie Road may yield sandy materials that could be utilised as bedding sand depending on grading.

6.6 BMA Pit

Location

Study of Google Earth indicates that the BMA Pit may be associated with a filled old channel of Nebo Creek between Cockenzie Road and the BMA easement to the south of where the BMA easement meets Cockenzie Road. This location is approximately 54 km from the proposed Connors River Dam or 92 km from the Moranbah terminal. The filled old channel may continue to the north of the current workings meandering along Cockenzie Road and it may extend to the south along the southern side of the BMA easement, crossing Cockenzie Road and meandering through the Braeside bore field to the east of Cockenzie Road. The section of this southern extension to the south of the BMA easement may have already been worked out. This area is currently a water storage associated with the Braeside bore field wash down facility.

Site Access

The BMA Pit and possible extensions can be accessed via the well maintained Cockenzie Road, BMA easement and access tracks within the Braeside bore field.

Description of resource

A visual inspection of the BMA Pit sand has not been undertaken.

Geological source

The BMA pit is located in an area of Quaternary alluvium containing sand, silt, mud, clay and gravel. The source geology of these sediments is that of Nebo Creek which is believed to have meandered over time from the BMA pit area to its current more easterly position.

Estimated Resource Extent
Study of Google Earth (refer Appendix C) indicates that approximately 27 750 m² of the old filled Nebo Creek channel extension to the north of the BMA Pit and 81 000 m² extension to the south (total 103 750 m²) may yield sandy materials that could be utilised as bedding sand depending on grading.

Any Other Comments
The gazetted Cockenzie Road, the buried water pipeline in the BMA easement and the infrastructure associated with the Braeside bore field will probably have to be maintained, limiting the extent of any extraction operations to this pit.

6.7 Denison Creek

Location
The proposed pipeline route crosses Denison Creek at approximately 48 km from the proposed Connors River Dam or 98 km from the Moranbah terminal. Denison Creek generally flows from the north north-east towards the south south-west in the vicinity of the proposed crossing point which is south of Waitara in the vicinity of the Hamilton Park pastoral property homestead and Washpool Lagoon. Denison Creek and its tributaries drain the western side of the Blue and Balaclava Mountains, the eastern side of the Pisgah Range and the south-east corner of a section of the Connors Range from the north north-east to south-east of Nebo.

Site Access
Study of Google Earth indicates that Denison Creek should be able to be accessed at two points via well maintained access tracks within the Braeside bore field, a poorly maintained farm track which crosses the watercourse and a power line easement or property boundary fence line which crosses the watercourse.

Description of resource
Sand from Denison Creek was not inspected during the site visit.

Geological source
The geology along Denison Creek is predominantly volcanic including the Lower Bowen Volcanics, the Urannah Complex and Tertiary volcanic flows and pyroclastics, but also includes Tertiary mudstone, siltstone, shale, sandstone and conglomerate. Nebo Creek flows into Denison Creek near the Hamilton Park Homestead, bringing with it sediments collected along its length and that of Cooper Creek.

Estimated Resource Extent
The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 62 050 m² of the bed of Denison Creek to the east of the Braeside bore field may yield sandy materials that could be utilised as bedding sand depending on grading.

Any Other Comments
Sand derived from the weathering of volcanic rock (as would be likely to be encountrered in Denison Creek and those creeks further east) are likely to have variable shape, particle size and alteration. Due to the variation in these and their influence on use as bedding sand, more extensive investigations would be required to confirm the resource than that required in the more western creeks with a more uniform geological origin.

6.8 Funnel Creek

Location
The proposed pipeline route crosses Funnel Creek at approximately 35 km from the proposed Connors River Dam or 111 km from the Moranbah terminal. Funnel Creek generally flows from the north north-east towards the south south-west in the vicinity of the proposed crossing point which is at the eastern power line easement crossing point downstream of where Boothill Creek joins Funnel Creek. Funnel Creek and its tributaries drain the southern end and south-east corner of the Blue Mountains, the north-west and north-east sides of Mount Scott and the Colstop, Bells, Bates and Hatfield Gaps sections of the Connors Range to the south-west of Sarina.

Sand deposits have previously been identified by others along easterly channels of Funnel Creek below the junction with Denison Creek where Funnel Creek becomes a braided system. In this area Funnel Creek generally flows from the north north-west towards the south south-east. This area is to the south south-east of the Cockenzie pastoral property homestead.

A sand deposit downstream of the junction of Funnel and Denison Creeks was visited during the site inspection. Study of Google Earth indicates that a larger area of river bed deposit (possibly sand) may have existed below the junction of Funnel and Denison Creeks.

Site Access

The north section of Funnel Creek is accessed along a poorly maintained gravel section of Tierawoomba Road, poorly maintained farm tracks and power line easements. The southern section is accessed along poorly maintained farm tracks and open country. Access to sand in the more southerly reaches of Funnel Creek would require construction of access tracks across soft, wet soils and potentially flowing channels.

Description of resource

Funnel Creek is a long creek with numerous creeks flowing into it, including Boothill and Denison Creeks. The connecting creeks will deposit sand of varying composition into Funnel Creek thus changing the nature and composition of the sand along its length. During the site visit sand from Funnel Creek was inspected at the junction of Boothill and Funnel Creeks (referred to as The Junction and described separately later) and south of the intersection with Denison Creek. At this southern location gravelly sand was observed on the right bank of the western channel of Funnel Creek. The fine to coarse sand and fine to medium gravel were typically sub-angular to sub-rounded quartz and lithic particles. On the western side of this water channel (of approximately 10 m width and 0.2 m depth) was a 2 m high sand bank that appeared to comprise a finer sand deposit, possibly medium to coarse grained.

14A – Upstream Right-Hand Bed

14B – Left-Hand Bed

Figure 14: Funnel Creek Downstream Denison Creek Junction

Geological source

Funnel Creek flows through geology of volcanic origin along its length with units intersected including the Lower Bowen Volcanics, Urannah Complex and Tertiary acid and intermediate flows, pyroclastics, basalt and minor porphyritic rhyolite. Boothill Creek flows into Funnel Creek at the Junction. Denison Creek flows in south of the Cockenzie Homestead.

Estimated Resource Extent

The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 407 100 m² of the bed of Funnel Creek to the south of the junction with Boothill Creek may yield sandy materials that could be utilised as bedding sand depending on grading. Of this area some 182 500 m² was associated with the area designated and photographed as Location E by SunWater at the PowerLink easement.

6.9 Boothill Creek

Location

Boothill Creek does not cross the proposed pipeline route. However Boothill Creek joins Funnel Creek approximately 3.5 km upstream of where the proposed pipeline route crosses Funnel Creek. Boothill Creek generally flows from the east north-east towards the west south-west and is crossed by the sealed Marlborough Sarina Road approximately 8 km from the junction with Funnel Creek. This crossing point is to the west of the Tierawoomba pastoral property homestead. Boothill Creek and its tributaries drain the southern side of Mount Scott, the northern side of the Pine Mountains and western side of the north-eastern spur of the Pine Mountains.

Site Access

The western section of Boothill Creek is accessed along a poorly maintained gravel section of the gazetted Tierawoomba Road on the southern side of the creek and poorly maintained farm tracks. Study of Google Earth indicates that the northern side of this section of the creek should be able to be accessed from poorly maintained farm tracks in a cleared corridor and open country. Study of Google Earth indicates that the eastern section of Boothill Creek should be able to be accessed at a number of points via the sealed eastern section of the Tierawoomba Road and poorly maintained farm tracks which cross the watercourse including the gazetted Rosedale Road.

Description of resource

Sand deposits along Boothill Creek were inspected during the site visit. At the Marlborough – Sarina Road bridge crossing of Boothill Creek a reasonable sized sand bank is present. The sand was typically medium to coarse grained with some fine gravel, sub-angular. The fines content increased in the vicinity of an old billabong and cobble content also increased. The sand bank was vegetated and also had significant organic matter lying on the surface. Further west along Boothill Creek, near a windmill, another sand deposit was inspected. At this location the material was gravelly sand with medium to coarse sand and fine to medium gravel, with some lithic (volcanic) fragments. Some organic matter was also observed at this site.

15A – Downstream Mid to Upper Right-Hand Bed

15B – Downstream Upper Right-Hand Bed Material

15C – Downstream Mid Right-Hand Bed Material

15D – Downstream Lower Right-Hand Bed

15E - Downstream Lower Right-Hand Bed Material

Figure 15: Boothill Creek Adjacent Marlborough Sarina Road

16A – Upstream Bed

16B – Downstream Bed

16C – Left-Hand Side Bed

16D – Typical Bed Material

Figure 16: Boothill Creek at Windmill

Geological source

The geology along Boothill Creek is volcanic and includes the Lower Bowen Volcanics, the Urannah Complex and Tertiary volcanic flows.

Estimated Resource Extent

The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 259 250 m² of the bed of Boothill Creek may yield sandy materials that could be utilised as bedding sand depending on grading. Of this area some 48 600 m² is associated with the relatively easily accessible Windmill section.

6.10 The Junction

Location

Boothill Creek joins Funnel Creek approximately 3.5 km upstream of where the proposed pipeline route crosses Funnel Creek. This area is locally known as The Junction. Boothill Creek generally flows from the east north-east towards the west south-west. As discussed above:

- Boothill Creek and its tributaries drain the southern side of Mount Scott, the northern side of the Pine Mountains and western side of the north-eastern spur of the Pine Mountains
- Funnel Creek and its tributaries drain the southern end and south-east corner of the Blue Mountains, the north-west and north-east sides of Mount Scott and the Colstop, Bells, Bates and Hatfield Gaps sections of the Connors Range to the south-west of Sarina.

Site Access

The Junction is accessed along a poorly maintained gravel section of the gazetted Tierawoomba Road which becomes the gazetted Waitara Hamilton Park at The Junction.

Description of resource

Material deposited at The Junction is a mix of sediment from Funnel and Boothill Creeks and is highly variable depending on location with respect to the channels and overflow areas. In the vicinity of the Boothill channel coarse sand to fine gravel including lithic (volcanic) particles were observed. In the larger open expanse medium to coarse, sub-angular to sub-rounded sand composed of lithic and quartz particles, with some coarse gravel to cobble clasts was observed. Superficial fines deposits were also observed in this area. In higher banks and under established trees, clay rich deposits were also seen. Along the main Funnel Creek channel out of the Junction water was flowing with only a narrow bank on the left comprising gravel and cobbles.

17A – Upper Downstream Bed

17B –Mid Downstream Bed

17C – Typical Bed Material

17D – Typical Dried Bed Surface Silt Patch

17E – Left-Hand Main Funnel Creek Channel

17F – Left-Hand Main Funnel Creek Channel Bed Material

Figure 17: The Junction

Geological source

Flow from both Boothill and Funnel Creeks come together at the Junction. Both these creeks traverse volcanic geology of the Lower Bowen Volcanics, Urannah Complex and Tertiary volcanics.

Estimated Resource Extent
The field inspection and study of Google Earth (refer Appendix C) indicates that approximately 59 350 m² of the bed of The Junction and Funnel Creek below The Junction may yield sandy materials that could be utilised as bedding sand depending on grading.

Any Other Comments
The gazetted Waitara Hamilton Park and Tierawoomba Roads bed-level crossing of Funnel Creek will probably have to be maintained, limiting the extent of any extraction operations.

6.11 Connors River

Location
The proposed pipeline route crosses the Connors River at approximately 5 km from the proposed Connors River Dam or 141 km from the Moranbah terminal. This crossing is adjacent to the junction of the Connors River with Sandy Creek (a tributary of the Connors River). The Connors River generally flows from the north north-east towards the south south-west in the vicinity of the proposed crossing point which is west south-west of Mount Bridget. The Connors River and its tributaries drain the southern and western sides of the Pine Mountains, the northern end of the Chinaman Ridges and a large section the western side of the Connors Range from Sugarloaf Mountain in the north to The Alps in the south.

Site Access
Study of Google Earth indicates that this part of the Connors River should be able to be accessed along the maintained, gravel, Connors River Collaroy Road, poorly maintained farm tracks and open country or poorly maintained farm tracks from the Marlborough Sarina Road.

Geological source
The complex volcanic geology of the Connors Range is the environment the Connors River flows through in its course south-west to meet Funnel Creek south of Mount Spencer. Geological units present along the path of the Connors River include the Lizzie Creek Formation, Leura and Connors Volcanics, Back Creek Group, Doreen Granite and Tertiary volcanics. The main rock types in these units are rhyolite, dacite, volcaniclastics, ignimbrite, pyroclastics, basalt, andesite and tuffaceous and volcanilithic sandstone.

Estimated Resource Extent
Study of Google Earth (refer Appendix C) indicates that approximately 228 300 m² of the bed of the Connors River at the Mount Bridget bend and the junction with Sandy Creek may yield sandy materials that could be utilised as bedding sand depending on grading.

Any Other Comments

Recent laboratory testing of alluvial material extracted from the Connors River, upstream of the proposed dam location, provide some indication of the suitability of this material for use as bedding sand. In particular organics, not visibly observed, were present in samples from the lower and upper terraces in amounts that fail Australian Standard 2758.1 compliance levels. Testing also indicated the presence of weak particles and failed to meet soundness criteria.

6.12 Discussions

The well graded quartz sand deposits present in the Isaac River appear from the desktop review and site visit to be consistent with the requirements of SunWater's bedding sand specification and also constitute the largest sand resource along the pipeline corridor. East along the pipeline route, the sand deposits appear to become finer, though still predominantly quartzose and derived from sedimentary rocks. Creeks immediately downstream of Coppabella Mine appear to contain stormwater run-off from the mine operations and stockpiles and are therefore likely to have increased fines contents. Further west, from Denison Creek onwards, the river sediments are derived predominantly from volcanic rocks. The sediments are therefore expected to be more variable in grain size, grain shape, mineral composition, particle strength and percent of fines. To assess the nature of the sand resource in this area a more detailed investigation would be needed than in the west to capture the variability.

As mentioned, the site of the largest possible resource is the Isaac River. It is a wide river and the bed can be readily accessed at a number of locations. The resources identified on the other rivers are typically much narrower and are accessed via steep river banks that would require significant tree clearing and earthworks to provide vehicular entry. Vegetation would need to be cleared and organic material screened out prior to use.

7.0 PERMITTING REQUIREMENTS

Under the Queensland *Water Act 2000*, a Riverine Protection Permit is required to investigate the potential to extract sand from rivers and creeks in the Moranbah and Nebo areas where vegetation or river banks is being impacted.

A Quarry Material Allocation Notice is required to extract sand from rivers or creeks in the Moranbah and Nebo areas.

7.1 Sand Source Investigation

Should vegetation clearance or river bank excavation be required to access the river bed for investigation purposes then a Riverine Protection Permit would be required. A Riverine Protection Permit allows the permit holder to remove native vegetation and excavate within a watercourse, provided material excavated is replaced and not removed from the site except for reasonable samples for off site testing. Information required to be submitted with the application for a Riverine Protection Permit includes:

- the proposed scope of works;
- a location map for investigation works;
- the details of vegetation destruction necessary for the investigation;
- the condition of the watercourse;
- the details of the investigation to be undertaken, including methods; and
- approval from registered landowners where investigation will be undertaken on or adjacent to private land.

A Riverine Protection Permit needs to be obtained for each river or creek, where investigations will be undertaken. No Department of Environment and Resource Management (DERM), previously Department of Natural Resources and Water, fee is associated with obtaining a River Protection Permit.

However, we understand that if there is to be no impact on vegetation or river banks then investigations could proceed without a Riverine Protection Permit.

7.2 Sand Extraction

A Quarry Material Allocation Notice (QMAN) gives an entitlement to the resource and allows the extraction of an allocated volume of sand from a specified river. A QMAN is only applicable to freshwater reaches of rivers and creeks and requires certain investigations depending on the extent of extraction.

Once an entitlement to the resource has been obtained from DERM, a Development Application needs to be submitted to the local council under the *Integrated Planning Act 1997*. The Development Application process includes completion of relevant Integrated Development Assessment System forms for each site and submission to local council with an Operation Plan and a Site Based Management Plan for each site where sand will be extracted.

An Operation Plan outlines details of the extraction process including:

- the type of machinery used

- the method of operation
- the depths of extraction
- the area of works
- details of oversize or spoil material
- details of rehabilitation
- material removal rate
- processing and stockpiling of material.

A Site Based Management Plan outlines the proposed activities, including extraction areas and volumes, and extraction methods. A Site Based Management Plan also outlines management of potential environmental impacts and management strategies for issues including:

- cultural heritage
- flora and fauna
- erosion and sediment control
- environmental nuisances
- water quality
- waste
- weed control
- rehabilitation.

A Geotechnical Report on Sand Resources Study and a Construction Environmental Management Plan should also be submitted as part of the Site Based Management Plan for each site.

DERM is still accepting applications for Quarry Material Allocation Notices for the Isaac River. While they are currently actively enforcing conditions on existing allocations, there is no widespread moratorium on extraction from the Isaac River.

8.0 RECOMMENDED INVESTIGATION

We recommend that the investigation of potential sand sources continues using a staged approach. This approach should minimise the permitting requirements in the earlier stages and allow identification of the most prospective sources prior to a more detailed and targeted investigation. The first stage of the investigation was the desktop study, the second stage of investigation would be aimed at:

- Providing a more detailed visual inspection of potential resource extents;
- Collection of representative samples for analysis of grading curves for comparison with SunWater's grading envelope; and
- Preliminary estimation of sand volumes through limited investigation of alluvium thickness.

8.1 Stage 2 Investigation Scope

Based on this, and following discussion with SunWater, we propose the following investigation scope for Stage 2.

- Isaac River
  - 12 No. Test Pits with sample collection along a 3 km stretch
  - Dynamic Cone Penetrometer (DCP) tests adjacent to test pit locations
  - 6 No. Particle Size Distributions
- North Creek
  - Visual inspection upstream and downstream of the pipeline alignment
  - 3 No. Hand auger holes with sampling and adjacent DCP testing
  - 2 No. Particle Size Distributions
- Harrybrandt Creek
  - Visual inspection of resources identified as part of this desktop study
  - 5 No. Hand auger holes with sampling and adjacent DCP testing
  - 3 No. Particle Size Distributions
- Bee Creek
  - Visual inspection upstream and downstream of the pipeline alignment
  - 4 No. Hand auger holes with sampling and adjacent DCP testing
  - 3 No. Particle Size Distributions
- Dennison Creek
  - Visual inspection of resource identified as part of this desktop study (refer Plate C14)
  - 3 No. Hand auger holes with sampling and adjacent DCP testing
  - 2 No. Particle Size Distributions
- Funnel Creek
  - Visual inspection of resources identified as part of this desktop study on Plates C21 and C29
  - 3 No. Hand auger holes with sampling and adjacent DCP testing in resource area identified on Plate C21
  - 4 No. Test Pits with sampling and adjacent DCP testing at the Junction (Plate C29)
  - 5 No. Particle Size Distributions
- Boothill Creek
  - Visual inspection of resource identified as part of this desktop study (refer Plate C27)
  - 4 No. Test Pits with sampling and adjacent DCP testing at the “Windmill” (refer Plate C27)
  - 3 No. Particle Size Distributions
- Connors River

- Visual inspection of Mount Bridget Band and Sandy Creek junction resource extents (refer Plate C29)
- 4 No. Test Pits with sampling and adjacent DCP testing at the Sandy Creek junction (refer Plate C30)
- 4 No. Test Pits with sampling and adjacent DCP testing at the Mount Bridget Bend (refer Plate C31)
- 6 No. Particle Size Distributions

An estimate of the cost to undertake the proposed Stage 2 investigations and to prepare a factual report of the findings and some comment on sand volume estimates and suitability has been prepared and is included in our proposal (ref: 144-077632049).

8.2 Investigation Permitting

Based on discussions with SunWater we understand that you will undertake consultation with Land Holders, arrange access to the sites for Golder, and will provide land holder approval letters to assist in application of Riverine Protection Permits. As part of our proposal for these works we will allow time for an upfront meeting with SunWater to discuss land holder arrangements.

It is also our understanding that SunWater will be responsible for all Cultural and Heritage arrangements and any limitations imposed by their requirements will be notified to Golder.

We understand that SunWater may choose to undertake the environmental permitting for the Stage 2 sand resource investigation. Based on our discussions with DERM the following outlines Golders' understanding of the steps required to achieve permitting for the sand investigation.

1) Database Search of existing Quarry Material Allocation Notices

A list of the rivers and creeks that we proposed to investigate would need to be provided to DERM to initiate the database search. DERM would provide the location of any allocations within the specified rivers by quoting adjacent Lot and Plan details. They do not provide details of the reach of the allocation.

2) Investigation into the Details of Existing Allocations

If the results of the first database are insufficient to determine locations of existing allocations in the vicinity of proposed investigation locations then DERM can undertake a more detailed search. The deliverable from this search would be a plan showing the area of the existing allocations.

3) Riverine Protection Permit

The proposed investigations in North Creek, Harrybrandt Creek, Bee Creek, Dennison Creek, Funnel Creek (south of the Junction) and Connors River are limited to hand augering and sampling and DCP testing. This hand held equipment will cause minimal disturbance to the river bed and does not require vegetation or river bank disturbance. We understand that given these conditions DERM does not require a Riverine Protection Permit to be obtained for the work.

The proposed investigations in the Isaac River, Boothill Creek and Funnel Creek (at the Junction) will include excavation of test pits using a backhoe. Formation of access to the river beds may require both vegetation clearance and river bank modification. The excavations themselves may be considered disturbance to the river bed and it would therefore be prudent to submit an application for a Riverine Protection Permit for DERM consideration.

Golder would be pleased to assist in the permitting steps outlined above and have included a cost estimate in our proposal.

8.3 Extraction Permitting

To obtain a QMAN from DERM an Application For Quarry Material Allocation form (ref: W2F009-v2) needs to be completed and submitted to DERM. The form requires the following details:

- Quarry Material Allocation Details – Quantity and Period
- Locality Details
- Location in Watercourse

There is a cost associated with the application. Once a QMAN is obtained, the process of obtaining a Development Application (outlined in Section 7.2) from the local council may commence.

9.0 LIMITATIONS

Your attention is drawn to the document - ~~L~~limitations", which is included in Appendix D of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

We would be pleased to answer any questions about these limitations from the reader of this report.

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