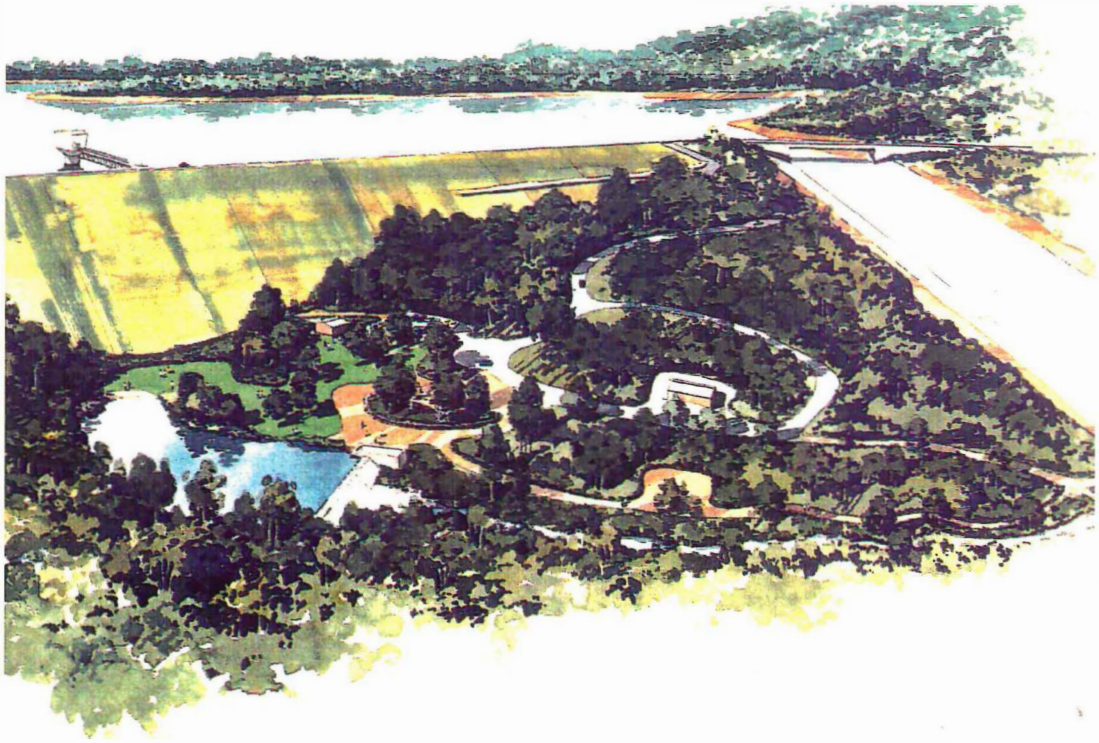
Water Authority
of Western Australia

North Dandalup Dam
Environmental Management Plan



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Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE
Water Resources Planning Branch
Dams Engineering Section

North Dandalup Dam
Environmental Management Plan

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Attention: Bob Wark

FAXED 20/12 J.Z.

NORTH DANDALUP EMP

The Department of Conservation and Land Management has reviewed the EMP, There are some specific management issues which have yet to be resolved, however the Plan adequately establishes the framework to address these and is acceptable to CALM. The following matters require addressing and qualify the previous statement.

* **Recreation Area Infrastructure, Access Roads and *Anthocercis gracilis*:**

  The plan makes cursory mention of the DRF *A. gracilis*. It is considered that development below the dam wall may possibly present problems for this population. In addition verbal advice from Bob Wark that there is a gradient problem with the access and that modifications are required further clouds the matter. A detailed report from your consultant regarding the *A. gracilis* population is required including an assessment of the likely impact of any development. It would appear that a general review of the below-wall developments is necessary. A review should involve Jeni Alford (Regional Ecologist) and Richard Hammond (landscape architect).

  It would be necessary to make available the report to Jeni Alford well prior to any meeting. I have not been able to confirm the meeting for the 6th with Jeni or Richard and will ask Jeni to leave you a message regarding this.

* **Dieback Interpretation (9.2):**

  It is only necessary to interpret the CALM resources below FSL. Interpretation for logging below FSL is not required outside these resources. Interpretation above FSL for 500 m buffer logging is required.

* **Land Exchange:**

  This matter still requires addressing and we would be pleased to hear your proposals.

for Syd Shea
EXECUTIVE DIRECTOR

20 December 1991

Dist: Eve Bunbury, EPA
Regional Manager, Swan Region
Richard Hammond – AA'd 20/12
District Manager, Dwellingup
Jeni Alford, Kelmscott – AA'd 20/12
– JENI. CAN YOU TAKE THIS ON BOARD & LEAVE

NORTH DANDALUP DAM PROJECT

ENVIRONMENTAL MANAGEMENT PLAN

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1. INTRODUCTION

North Dandalup Dam is planned to be the next major public water supply source for Perth. It will replace the existing North Dandalup Pipehead Dam and add a further 11.2 M.cubic.m/yr to the system yield. The current Source Development Timetable requires the new dam to be ready to supply water to the system by summer 1994/95. To achieve this timetable, tenders need to be called in March 1992 and a 2 year contract for construction awarded in August 1992.

The Authority prepared an Environmental Review and Management Programme (ERMP) for the Next Major Public Water Supply for Perth (Post 1992) in 1988. This Stage 1 ERMP showed the need for a new source; and showed that of the options available, North Dandalup Dam is the best source for development. The ERMP also establishes that there are no adverse impacts, either locally or for the region, the significance of which would make the development of North Dandalup Dam environmentally unacceptable.

Following an EPA review of the Stage 1 ERMP, the Minister for the Environment gave approval in August 1988, to construct North Dandalup Dam. The project is subject to a number of conditions set by the Minister and commitments given by the Water Authority. These are set out in Section 2 together with brief comments and references to the proposed actions to be taken. More detailed information on proposed environmental control during the project is given in the subsequent sections.

As the project proceeds, the EPA will be kept informed by regular reporting similar to that established for the Harris Dam project.

2. ENVIRONMENTAL MANAGEMENT COMMITMENTS

The following set of environmental management conditions have been taken from the Minister for Environment's documentation formally approving the project.

1. The proponent shall adhere to the proposal for the North Dandalup River as assessed by the Environmental Protection Authority and shall fulfill the commitments made in the Environmental Review and Management Programme.

2. Prior to construction, the proponent shall prepare and subsequently implement to the satisfaction of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Conservation and Land Management, an Environmental Management Programme for the North Dandalup dam which shall include details of the following:

   (i) environmental consequences of road deviations;

ACTION; Will require a more detailed examination of the road routes after completion of the preliminary phases of the route planning. More details are given in section 5.

(ii) source of construction materials;

ACTION; The sources are discussed in Section 6.

(iii) the management of environmental impacts in the reservoir, dam and immediate downstream sections of the river and valley during and following the construction phase, including the mitigation of impacts upon habitats.

ACTION; The following sections of the EMP outline the various measures which are proposed to be taken to minimise the impact of the project. These have been developed following further detailed environmental evalautions outlined in Section 3 and more detailed planning which has been completed since the ERMP was prepared. Proposals for on-going monitoring are developed in Section 11 and other parts of the report, including commitments to modify the programme in consultation with the relevant authorities.

3. Prior to construction, the proponent shall prepare a plan pertaining to the management of the environmental impact of the proposal on Reserve C21038. This plan shall be prepared by the proponent in consultation with the department of Conservation and Land Management and to the satisfaction of the Minister for the Environment on advice on the Environmental Protection Authority, and shall include the following:

(i) proposals for the excision of the dam wall and spillway areas from Reserve C21038;

ACTION; Overall plan of excision of area for dam and pipeline track as currently proposed is at Section 7.1.

(ii) management of public access to the Reserve;

ACTION; Discussions have been held with CALM on proposals for recreation around old pipehead dam, the current proposal is discussed in Sections 4.9, 4.10 and 7.2.

(iii) impact of spillway waters on the stream zone;

ACTION; Details of spillway stilling basin and performance are discussed in Section 7.3.

(iv) impact of the pipeline and maintenance road;

ACTION; Detail of proposal for pipe and access road (Section 7.4).

(v) rehabilitation of the pipehead dam site.

ACTION; Discuss incorporation in landscape plan concept for site, possible retention of water body on downstream side, emoval of screening building etc (Section 7.5).

4. Before final decisions are made on the raised Mundaring and raised Canning options, the proponent shall refer detailed proposals for each of these sites to the Environmental Protection Authority.

ACTION; No action required on this item

5. To minimise dust and soil erosion:

(i) clearing will be restricted to the minimum required for safe access and construction;

ACTION; Controlled through Contract documentation

(ii) wherever possible, existing roads will be used for clearing and construction activities:

ACTION; Include from project report

(iii) earthworks and other soil-disturbing activities will be carried out only during the dry summer months;

ACTION; Controlled through Contract documentation

(iv) working areas prone to dust production or other erosion will, where necessary, be surfaced or watered;

ACTION; Controlled through Contract documentation

(v) the area upstream from the dam wall and below full supply level will be utilised, where feasible, for lay-down and other construction-related purposes and as the source of most of the sand, gravel and other available material required for construction;

ACTION; Controlled through Contract documentation

(6) To minimise impacts on existing native vegetation and flora:

(i) additional flora and vegetation surveys will be undertaken to confirm or refine descriptions contained in this report and facilitate detailed project design causing minimum adverse impact;

ACTION; The additional surveys have been completed and are reported in (Section 3.2).

(ii) areas to be cleared will be carefully delineated;

ACTION; Controlled through contract documentation

(iii) the construction workforce will be given specific directives to clear only within the delineated areas and to avoid unnecessary damage to vegetation;

ACTION; Controlled through contract documentation

(iv) vehicular movement will be confined to specified roads and tracks;

ACTION; Controlled through contract documentation

(v) all construction operations will be subject to Department of Conservation and Land Management forest hygiene requirements; and

ACTION; Controlled through contract documentation by project managers

(vi) liaison will be maintained with the Department of Conservation and Land Management in accordance with these requirements.

ACTION; Will be undertaken by the Project Managers

7. Rehabilitation of disturbed areas will aim to create self-sustaining systems of native species.

ACTION; An overall landscape plan will be used to delineate the end uses for each area of the works. Specific requirements will be included in Contract Works to cover these areas.

8. To minimise inconvenience to residents nearest the dam site and along access roads:

(i) noisy, heavy equipment will operate along Hines Road only during daylight hours;

(ii) unsealed portions of roads near residences will be sealed or watered to prevent dust production;

(iii) residents will be fully informed of any blasting operations. Furthermore, everyone will be excluded from the danger area during shot-firing.

ACTION; Controlled through contract documentation

9. To minimise inconvenience to and adverse effects on the construction workforce:

(i) working areas will be sheeted with gravel or, where acceptable or preferable, watered by a water tanker fitted with sprays; and

(ii) where appropriate, employees will be issued with equipment to protect them from unacceptable levels of dust and noise.

ACTION; Controlled through contract documentation

10. To maintain and increase the aesthetic and recreational potential of the project area:

    (i) all oils, fuels and other chemical products will be stored and used according to the requirements of the appropriate regulations;

    (ii) special care will be exercised in the storage and handling of petroleum-based products to prevent contamination of surface soils, rock surfaces and water by oil and fuel spills;

    (iii) all wastes will be collected in a sump and trucked to an approved waste disposal site; and

    (iv) sites for picnics, barbecues, information and ablution facilities and bushwalking trails will be selected, developed and landscaped to blend in with the surrounding natural environment.

ACTION; Controlled through contract documentation

11. The Water Authority is not required by law to release any water stored behind the proposed dam. However, in view of the possible adverse impact on riparian users, the Authority will review present use of the river flow and will determine, in consultation with existing riparian landowners, a satisfactory arrangement for meeting the genuine and reasonable domestic, stock and garden watering requirements of the landowners. If the arrangement arrived at is to release prescribed flows, the amount released would not exceed the natural stream flow into the reservoir at the time and no water would be released in periods when the natural stream flow ceased altogether.

ACTION; The agreement reached with the Minister for Water Resources will address these issues, including releases down the river and from Harvey Diversion (Section 8).

12. To minimise impacts on native fauna, an ecological study and monitoring programme will be designed and undertaken to assess stream flow-related requirements of local fish and other aquatic fauna, including exotic species, and to detect changes in their populations which might be related to operation of the dam. The information will be used for planning future water supply projects and in managing North Dandalup River flows in ways most beneficial to aquatic fauna. The aquatic investigations presently being conducted for the Water Authority by the University of Western Australia will provide a sound contribution to designing these studies and the management framework.

ACTION; Refer to sections 3.6 and 11.1.

13. The project will be carefully designed and managed, in consultation with the Department of Conservation and Land Management, to preserve the conservation value of the remaining reserve as well as to minimise environmental impacts on the excised portion. The management measures to achieve this during the construction and operation phases of the project will be reviewed through the preparation of an appropriate plan to manage the environmental impacts of the proposal.

ACTION; Will be covered under action points 2 and 3

14. The Water Authority acknowledges its obligations to site protection as outlined in the Western Australian Aboriginal Heritage Act, 1972-80, and has accordingly sought and obtained approval from the Minister for Aboriginal Affairs to use the area at North Dandalup for development of a dam.

ACTION; None required on this point

15. Any new sites discovered during the course of dam construction and associated work will be reported to the Registrar of Aboriginal Sites.

ACTION; To be followed up during construction

3. ADDITIONAL ENVIRONMENTAL DATA

3.1 Scope of work

Since completion of the ERMP "Next Major Public Water Supply Source for Perth (post 1992)" in 1988 the Water Authority has pursued a number of strategic environmental studies to improve knowledge of both the specific North Dandalup environment and, more generally, the impacts on river systems of water supply developments.

Reports on the following studies have been prepared for use within the Authority:

- "Flora and Vegetation of the North Dandalup Dam Site", Havel Land Consultants, March 1988;

- "The Effect of Fluctuating Water Levels in Reservoirs on Fringing Vegetation, and of Modified Stream-flows on the Vegetation Downstream from the Reservoirs", Havel Land Consultants, June 1988;

- "The Effect of Dams in the Darling Range upon the Red-eared Firetail Emblema oculata", M J Bamford, Royal Australasian Ornithologists Union, April 1989;

- ARL, 1988a. North Dandalup stream fauna study, Results and recommendations 1984-1987, Report 9, Aquatic Research Laboratory, University of Western Australia.

- ARL, 1989. Lower North Dandalup River catchment stream fauna study, Results and recommendations 1988, Report 16, Aquatic Research Laboratory, University of Western Australia.

- ARL, 1991. Biological energy flow in a lower river ecosystem, Report 19, Aquatic Research Laboratory, University of Western Australia.

3.2 Flora and Vegetation

The purpose of this study was to refine the understanding of the geomorphology, flora and vegetation of the North Dandalup dam site, reservoir basin and adjacent catchment as an input to detailed project design and implementation monitoring.

The study involved supplementary botanical collection and the survey of seven vegetation transects in addition to the ten studied during the 1986-87 ERMP investigations. This effectively halved the distance between transects and also ensured maximum coverage of the range geomorphic and vegetation features identified by aerial photo-interpretation as represented in the area. The number of vegetation survey sites (transect segments) was almost doubled by this work.

Based on this work a site-vegetation map of the reservoir area and immediate surrounds was produced (Havel Land Consultants 1988a). Although the list of site-vegetation types in the area was expanded, none were identified which were not covered by Havel's 1975 classification, with the exception of an area of introduced species on an abandoned farm site.

Recommendations on clearing of the reservoir basin were made based on the species which would not tolerate flooding and retention of those which it was believed would survive the frequency and duration predicted for the North Dandalup reservoir. Simplified, those upland types close to the dam wall should be cleared prior to first filling and the lowland types in the headwaters of the reservoir subject to occasional inundation can be retained helping to preserve their rich fauna. This study identified the value in further work to more confidently predict the response of intermediate vegetation types to flooding (see section 3.3 below).

The number of plant species identified at North Dandalup increased to 268, 252 of which are found within the area to be impacted by reservoir inundation. An analysis of the rate of new species collection versus survey effort indicates that the majority of species have now been found and the total number is unlikely to exceed 300 (Figure 1, Havel Land Consultants 1988a). Havel's conclusion is that no further flora surveys are warranted. None of the species found are gazetted protected flora. Boronia tenuis, found in the area of the spillway and previously a gazetted species, is a CALM "Priority Species" (Priority 3) considered to require further monitoring. [Recent and as yet unreported work by Havel has located a Priority 1 Species Anthocercis gracilus and a Priority 5 Species Senecio leucoglossus in the reserve downstream of the dam project]

The report also contained recommendations on road and forestry track relocations which are addressed in section 5 of this management plan.

3.3 Impacts on Vegetation

Consultants undertaking studies of alternative major water supply sources for Perth in 1986-87 (Havel Land Consultants 1987, Ian Pound & Associates 1988) identified the need to further investigate the impact that reservoir inundation had on remnant and regrowth fringing vegetation and the effect that regulation of stream-flow had on vegetation downstream of the dam. The information was sought in order to:

- permit more confident prediction of the affect of future surface water source developments in terms of vegetation clearing required; and, of more immediate importance

- facilitate design of impact mitigation strategies for North Dandalup, such as retention of vegetation within the reservoir area in circumstances where the native vegetation would survive inundation.

In the autumn of 1988 Havel conducted an investigation at Canning, Wungong and South Dandalup Dams, all of which were cleared of vegetation to nominal Full Supply Level (FSL) or even Maximum Flood Level (MFL) at the time of construction. The study characterised the current distribution and composition of vegetation in the headwaters of the reservoirs and below the dams, compared this with the vegetation which it is thought would have been present prior to the water resource development and correlated any observed differences with historical clearing, inundation and water releases. From the results of this work Havel concluded that:

- following vegetation clearing, if inundation did not take place, vegetation regrowth took place rapidly in the upper reaches of the reservoir basin, such that within 5 years the density of cover and quantity of decomposable organic matter was comparable to that prior to clearing. Therefore, under these circumstances, clearing for the purpose of water quality protection was defeated;

- following clearing, inundation and recession of the reservoir water, areas on steep upland slopes nearer the dam wall showed little sign of vegetation regeneration , whereas in areas on mild slopes in the upper reaches of the reservoir, vegetation returned to the extent that after a decade the quantity of readily decomposable organic matter (leaf and twig not basal area of trunks) had built up to pre-clearing levels, negating the long-term benefits to water quality of clearing;

- no significant changes in downstream phreatic and aquatic vegetation could be detected which were attributable to modification of stream-flow associated with dam operation. Metropolitan dams are located in the highest rainfall zone of the Darling Range and high rainfall run-off and stream regeneration immediately downstream of the dams is believed to adequately support the vegetation.

Before this work can be applied to the North Dandalup situation, it is necessary to look at the expected operating characteristics of the proposal as shown in table 3.1.

Table 3.1 Storage Behavior Data - North Dandalup Dam

Storage Volume	Storage Level m AHD	Frequency %	Average Duration months	Return Period Years
75	218.8	8	2.5	2.5
70	217.7	16	4.5	2.3
65	216.6	25	6.0	2.0
60	213.0	57	7.0	1.0

The frequency noted in Table 3.1 is the percentage of time that the reservoir level is at or above the figure shown. Analysis of the storage behavior (Figure 1 and Table 3.1) expected for the reservoir suggests that it will fill to near overflowing once every two to three years and that the reservoir will be within a few metres of the full supply level for considerable periods of time.

From the work by Havel and past experience of the Water Authority it has been possible to determine a vegetation clearing prescription for North Dandalup (see section 4.8) which will:

- remove in a timely fashion most of the vegetation from within the basin as this would not survive the predicted regime of inundation, and subsequently contribute to a water quality problem in the reservoir;

- retain in the reservoir headwaters, vegetation which it is believed will survive inundation with the attendant benefits in soil stability and vegetation and fauna preservation.

Havel's work also indicates that the phreatic and aquatic vegetation in the Helena landform (characterised by steep, narrow, rocky and fast flowing stream) downstream of North Dandalup Dam will not be adversely affected by further river regulation.

3.4 Vegetation Monitoring

3.4.1 Scope

Permanent vegetation monitoring transects have been established (pegged and surveyed) across the headwaters of the proposed reservoir and the river below the proposed dam to monitor the impact of dam and reservoir establishment on phreatic vegetation and adjacent upland complexes.

The rationale for the establishment of the transects is that whilst it is possible to anticipate the impact of the project on the basis of the preliminary impact assessment and associated studies, there is a need to actually record the impact on the basis of pre- and post- construction studies. This needs to be done not only in order to check

the predictions already made, but also to improve the basis on which the environmental impact assessment of future projects can be made.

3.4.2 Location of the Transects

The location of the transects was influenced by earlier studies, firstly the vegetation surveys of the area likely to be affected by the project, namely the area to be inundated and the area at and below the dam wall, and secondly by the studies of the impact water level fluctuation within and downstream of the reservoir on the surrounding vegetation. The latter were carried out on four dams that have been in operation from 10 to 60 years, and indicated that in upper reaches of the dams vegetation tended to return following the initial overclearing, and that below the dams the main form of impact was the deposition of clay and silt on the stream bed during and after the dam construction.

Two of the transects are located in the Foster upper reaches of the reservoir, on the river itself and of its tributary, the Brook, within the Murray and Myara landforms respectively. The intention is to define the degree to which the vegetation of the river banks can tolerate short term inundation, so as to minimise the extent of clearing consistent with the maintenance of adequate water quality. The third transect is situated downstream from the dam wall just within the boundary of the important reserve no. 21038, and is intended to monitor the impact of the dam construction on the vegetation of the reserve, including some species listed as being in need of survey and monitoring.

The fourth transect is on similar site to the previous transect, but located well within the reserve, so that it is unlikely to be affected by the project. It will however, be affected by climatic fluctuations, and will therefore make it possible to separate the effect of climate on the rare species form the impact of the project itself. This is important as the reserve and the dam wall are situated within the drought-prone Helena landform with shallow stony soils.

3.4.3 Size and Structure of the Transects

Each of the three main transect consists of a series of contiguous 20 x 20 m plots spanning that portion of the valley that could be affected by the project. A complete enumeration of all trees, in terms of species, number of stems, their diameters and the height of the tallest tree, has been carried out on the plot. Within each plot, four 1 x 1 m quadrats have been established for the enumeration of the shrub and herb species in terms of their height and cover percentage. In addition, each major plot has been photographed from each of its four corners to provide the visual record of the vegetation prior to impact.

The fourth transect [control] consists only of a linear baseline linking 1 x 1 m quadrats at the spacing of two quadrats/ 20 m. This transect is designed and located so as to give maximum information on the three rare species within the reserve, namely Boronia tenuis, Anthocercis gracilis and Senecio leucoglossus. The lengths of the four transects are 80, 80, 160 and 120 m respectively. The plots within the reserve have been established with particular care, so as to minimise their impact on the vegetation.

3.5 Impact of Dams in the Darling Range upon the Red-eared Firetail Emblema oculata

The Red-eared Firetail is the only representative of Australia's 19 finch species to occur in the south-west and was considered to be rare and restricted by CALM (Bamford 1989) [the Red-eared Firetail has been re-Gazetted from Schedule 1 to Schedule 2, ie from Rare or in Danger of Extinction to in Need of Special Protection]. Its range has significantly contracted due to clearing for agriculture on the coastal plain, and mining, forestry and dam construction in the jarrah forest. The species was until recently believed to habitually live in the dense, stream-zone vegetation of the jarrah and karri forests and some heath-lands on the south coast.

With these factors in mind it was postulated that future development of dams in the Darling Range could contribute further to the decline in Red-eared Firetail numbers by direct clearing of restricted habit and, more importantly, by fragmentation of stream-zone habitat above and below reservoirs. In the latter case it was suggested that an obligate stream-zone species such as the Firetail might become progressively isolated in smaller populations without genetic mixing and far more vulnerable to loss from that stream.

To test this hypothesis Dr Bamford of the RAOU was engaged to census Firetail populations over four periods at two sets of sites: above existing dams in the Darling Range and in similar habitats on streams not associated with dams. Two further species, the White-breasted Robin and the Red-winged Fairy-wren, although more widespread than the Firetail are also usually associated with dense, riparian vegetation and this study was designed to provide information on their distribution and any effect dams might be having on their numbers.

The study (Bamford 1989) concluded that in relation to the Firetail "no adverse effects of dams were found, probably because the previously unrecorded movement patterns mean that the birds are not isolated in suitable patches of riparian vegetation by dams, as had been suspected might occur". The study did however identify the fact that "the presence of breeding adult birds was determined by the density of the vegetation in the adjacent forest" and is therefore "sensitive to forest and catchment management". The study suggests that in relation to the Robin and

Fairy-wren "the fragmentation of riparian vegetation has no adverse affect upon them".

In view of these conclusions no further work has been pursued by the Water Authority for the purpose of planning the North Dandalup project, but the results of the study will be considered in catchment management. Conclusions of the study with regard to the incremental loss of habitat due to various land uses, including dam building, will be considered in evaluating the impacts of future dam proposals.

3.6 Aquatic Fauna

3.6.1 The Impact of Dams on Aquatic Fauna

The impact of river impoundment and flow regulation on downstream ecosystems has been described by a number of authors (Petts, 1984; Boon, 1988; Mann, 1988). Although the majority of the research in this area has been undertaken in Europe and North America, the general principles are applicable to Western Australia, and have been confirmed by work undertaken by the Aquatic Research Laboratory on a number of hills streams in the Perth Region (for example, see ARL, 1988a; ARL, 1988b).

Macroinvertebrates

Macroinvertebrate communities in streams are a result of complex interactions between physical factors such as stream flow, water temperature and substrate, and biotic factors, such as competition and predation, food sources etc. Invertebrate communities are generally adapted to a specific set of conditions including natural variability in the flow and temperature regime of streams. In fact the heterogeneity of streams is in part responsible for the high species diversity found in most undisturbed lotic macroinvertebrate communities.

In Western Australia, the impact of dam construction has been found to contribute to a decline in the species diversity of the community, and an associated increase in the abundance of some species. The reasons for these changes are thought to be due to the creation of more uniform habitats below the reservoir. Dam construction leads to lower and less variable flows with consequent build up of organics and sediments. This in turn leads to increased growth of aquatic plants and associated reduction in the diversity of the fauna. The lack of variability enables species particularly suited to the uniform conditions to dominate.

Apart from altering the diversity and abundance of the existing community, river impoundments also lead to a shift in species from those suited to a lotic habitat, to those which favour more intermittent flows and still water conditions. One of the main mechanisms of recolonisation and genetic mixing of macroinvertebrates is through downstream drift of species. Reservoirs prevent this drift, and where water releases from the reservoir occur, any

replacement of fauna by downstream drift will be of species in the reservoir which are adapted to the still-water environment.

Fish

There are only a small number of native fish species which have been recorded in scarp streams in the Perth region. Reservoirs are thought to impact on these species in a number of ways.

Species which favour lower flow conditions and higher water temperatures are likely to become more dominant. In Western Australia, the introduced mosquito fish, Gambusia affinis, has been observed to dominate in lower streams below reservoirs. This species favours still, warm waters, and it was believed to be responsible for displacing native fish species where it occurs (ARL, 1988b). However, a recent paper (Pen and Potter, 1991) concludes that within lotic waters, the indigenous fish species are not under severe threat as a result of the introduction of mosquito fish.

In studies on the Canning Reservoir catchment, the effect of the barrier formed by the dam wall has been suggested as an explanation for the absence of Tandanus bostocki from the headwater streams where it was expected to occur. The Canning catchment streams are intermittent, and rely on upstream migration for recolonisation of this species. The most southerly and only permanent headwater stream in the catchment was found to contain populations of this species.

Upstream migration is also important for spawning of some species, and this has been suggested as having a possible impact on the reproduction success of Galaxias occidentalis where it cannot negotiate river barriers such as dam walls.

The prevention of upstream migration by dam walls may lead to genetically isolated populations of some species. This could lead to inbreeding of the populations, reducing genetic diversity and making them less tolerant of changes to habitat conditions.

Where river impoundment leads to changes in the macroinvertebrate community, this also has potential impacts on fish species through alteration of their food source.

On the North Dandalup river the fish populations above the pipehead dam are already isolated through the inability of fish to negotiate the wall. In addition, the Scarp itself creates a natural physical barrier for fish movement. Therefore, construction of the North Dandalup Dam does not create a new problem in this respect.

3.6.2 The Existing Quality of the North Dandalup River

As part of the environmental impact assessment of the proposed North Dandalup Dam, and in order to provide a

baseline for biological monitoring of the Dam's impact, the Water Authority has contracted the Aquatic Research Laboratory at the University Western Australia to undertake a number of biological studies on the existing aquatic environment. These studies have been in progress since 1985, and a number of reports have been published (ARL, 1988c; ARL, 1989; ARL, 1991).

Macroinvertebrates

The above studies have found that the stream fauna of the upper North Dandalup catchment is indicative of relatively undisturbed, healthy systems. The macroinvertebrate communities in these streams have a high species richness and diversity, and low abundance. In contrast, the lowland sites, below the existing pipe-head dam, demonstrated a low species richness and high abundance, particularly in late summer and autumn. These characteristics are indicative of disturbed systems, influenced by organic enrichment from surrounding agricultural practices.

A sampling site located below the existing pipehead dam, but above cleared agricultural areas, indicated a fauna which receives intermediate levels of disturbance. Although the pipehead regularly overflows in both summer and winter, the pipehead diverts all of the spring and autumn flows, thereby significantly changing the downstream flow regime during these times. The site exhibited a decreased species richness and slightly increased abundance, somewhere intermediate between the upland and lowland sites.

Fish

Sampling indicated 8 species of fish present in the North Dandalup system, two of these being introduced species. Only two native species, Galaxias occidentalis (western minnow) and Bostockia porosa, and the introduced species Salmo gairdneri (trout) were found above the existing pipehead dam. Consistent with disturbed areas with low flows and warm water, mosquitofish were found in abundance in the majority of lowland sites.

Although trout were found both above and below the dam wall, its abundance was low and this is attributed to high summer water temperatures which are lethal to the trout. It is thought that the pipehead dam may act as a summer refuge, enabling recolonisation of the streams during winter.

The only migratory species, the western minnow, was found at all sites, both above and below the pipehead dam. It was thought to migrate upstream with the first winter rains to spawn in the headwater streams, but more recent evidence suggests that lowland species spawn in drainage channels and flooded areas during winter and do not move upstream onto the scarp. Therefore, although it cannot negotiate the existing dam wall, it is not thought that this interferes with its breeding cycle.

All species of fish are prevented from moving upstream past the pipehead dam. Individuals of those species above the dam may only move downstream during winter when swept over the dam wall by high discharge. Therefore, upstream populations are isolated. However, in terms of migration, the Scarp itself poses a significant natural barrier and may be responsible for the existing differences between upstream and downstream sites.

3.6.3 Specific Predicted Impacts of the North Dandalup Dam

On the basis of the existing condition of the North Dandalup River, and on observed conditions above and below existing dams on the Darling Scarp, the likely impact of the construction of the dam on aquatic fauna can be predicted. Most of the material in this section has been drawn from ARL, 1988.

Macroinvertebrates

Dams inevitably lead to changes in downstream water flow and temperature regimes, and this then results in changes to macroinvertebrate populations and community structure.

Construction of the North Dandalup Dam is likely to further compound the changes in macroinvertebrate fauna already observed through the impact of the pipehead dam. Between the Dam site and the coastal plain, this will be a further reduction in species diversity and richness, and possibly increased abundance of several opportunist species. The community is likely to shift to one more representative of still or low flow environments. However, the extent to which this happens depends on the input from downstream tributaries, the area of the river catchment which is below the dam wall, and the downstream release strategy from the reservoir. Because of the proximity of the Dam to the scarp, the length of river affected by these changes is not large.

The stream fauna in the River on the coastal plain is already quite degraded through the input of nutrients and pesticides from agricultural practices. Dam construction is unlikely to have significant changes on this part of the River, partly due to the resetting of the fauna which will occur through the input of tributaries, and the inflow of groundwater to the River on the Swan Coastal Plain.

The dam will form a physical barrier which may interfere with the upstream movement of some species of aerial, egg-bearing, adult stages of macroinvertebrates. However, the implications of reduced gene-flow between populations of macroinvertebrates in such a situation is not known.

Fish

As was noted earlier, fish populations above the pipehead dam are already isolated through the inability of fish to negotiate the wall and the Scarp itself creates a natural physical barrier for fish movement. Construction of the

North Dandalup Dam does not create a new problem in this respect. ARL (1988d) have discussed the impact of impoundments on the genetic structure of populations of G occidentalis in northern jarrah forest streams. This found that they appear to have no direct effects on the genetic composition of the species. It appears that the Darling Scarp is a natural barrier to gene flow and that Scarp and coastal plain populations exist in the species. As discussed above, it is also thought that the coastal plain species breed on the plain, migration not being essential for reproductive success.

There may be one area where the isolation of the upstream populations will have a negative impact. The existing and new dam will prevent recolonisations of the upstream populations of G occidentalis and B porosa should they decline for any reason. This could happen if the headwater streams were to completely dry. However, given the past permanence of the North Dandalup headwater streams, this would only be likely to happen in prolonged periods of exceptionally dry weather.

The body of still water created by the Dam is likely to act as a summer refuge for trout when water temperatures of the headwater streams become high. Trout populations will probably expand in the dam, resulting in reduced numbers of native species on which they are thought to prey.

The Swan Coastal Plain sections of the river contain abundant populations of mosquitofish. If the new dam results in appreciable reduction of summer flows in the River on the Plain, the numbers of mosquitofish may further increase. However, given the recent findings of Pen and Potter (1991), this may not impact on the populations of native fish.

4. PROJECT DESCRIPTION

4.1 Scope of works

The works will consist of main and saddle embankments containing over two million cubic metres of fill, a spillway, intake tower, outlet works and water treatment building. The dam will create a reservoir with a storage capacity of 75 million cubic metres as proposed in the Stage 1 ERMP, with a yield of 22 million cubic metres per year. Water will be delivered into the metropolitan system through the existing North Dandalup supply main.

The reservoir will have a surface area of just over 500 hectares which will be largely cleared as part of the project. Other works associated with the project include road upgrading and rerouting works, minor modifications to the existing pipeline, new water release works, modification of the existing pipehead dam facility to incorporate it into the new works. together with site restoration and rehabilitation, landscaping and facilities for public amenity.

The current programme of works is to commence some of the establishment work such as road upgrading and communications facilities during the first half of 1992, awarding a contract for the construction of the main civil works in August 1992, with the major construction being undertaken during the 1992/93 and 1993/94 summers. The dam would be completed ready to store water in the 1994 winter, with the first water deliveries scheduled for the 1994/95 summer.

4.2 Main Dam Embankment

The 60 metre high main embankment (Figure 4) will be located about 200m upstream of the existing pipehead. The crest of the embankment will be about 700m in length, 5m above FSL of 219m AHD. The crest will be 10m wide to carry the diverted Scarp Road across the top of the dam (Figure 3).

The dam structure will comprise a central earth rockfill section, flanked by abutment sections of homogeneous earthfill.(Figures 4 & 5). Graded transition filters will separate critical earth/rockfill contacts and a chimney filter and downstream drainage blanket will provide seepage pressure control in the earthfill abutment sections.

The composite construction of the embankment is related to the foundation conditions. In the valley floor, the fresh to slightly weathered, largely granitic bedrock is present at shallow depths. In the abutments, the bedrock gets progressively deeper, reaching 20-30m depth at FSL of 219m AHD.

The central rockfill section is founded throughout its width on bedrock, whereas the abutment earthfill sections only extend down to bedrock over the base area of a centrally placed, earthfill cutoff (Figure 5). The earthfill cutoff extends into the abutments, to control leakage around the

ends of the dam. Seepage through the underlying bedrock is controlled by a cement grouting.

An upstream clay blanket is included over the upper slopes of the reservoir basin for the dual purpose of reinforcing seepage control in the abutments and for limiting turbidity in the reservoir, resulting from erosion of semi-dispersive abutment soils.

4.3 Saddle Dam Embankments

Two saddle dams are required on low lying ridges to the north of the main dam (Figure 3). The structures will be homogeneous earthfill embankments of about 22m and 9m in height, crest lengths of 345m and 95m and embankment volumes of 275,000 and 26,000 cubic metres respectively. Downstream drainage blankets and a chimney filter, form part of the embankments.

Foundation conditions under both saddle dams are unusual for the Darling Scarp region as they largely comprise heavily indurated conglomerate material. The conglomerate outcrops in the middle of larger saddle dam and varies in depth to more than 60m at the right abutment of the smaller saddle dam (Figure 3). The material is made up of variably weathered granite and dolerite cobbles and boulders increasing in density and decreasing in weathering with depth in an indurated matrix of clayey silty sand and grit. The degree of bonding and induration increases with depth. The more clayey matrix soils, which are found particularly in the top 10m depth, are frequently dispersive.

Testing indicates the more permeable materials are found in the top 10m where laterisation is common, whereas very low permeabilities were recorded in the conglomerate at depth. The left abutment of the larger saddle dam contains residual granitic soils, up to 20 m in depth, overlying granite bedrock intersected by dolerite dykes.

Measures to limit seepage through the foundations are provided by a combination of earthfill cut-offs excavated to a depth of up to 10m, grouting and an upstream clay blanket. The latter will extend upstream over the area of exposed conglomerate in order to control stored water turbidity attributable to dispersive material in the conglomerate matrix.

4.4 Spillway

The largely unlined stepped spillway (Figure 6) is located on the left abutment to take advantage of the relatively shallow bedrock at that location. The spillway will be designed for the probable maximum inflow flood currently estimated at 1140 cumecs. Preliminary design has identified the optimum combination of a 55m wide spillway crest at a level of 219m AHD with an embankment crest level of 224m AHD. Further design work is proceeding on refining these preliminary design parameters.

The stepped chute of the spillway will be excavated for sufficient depth into fresh rock to ensure that erosion of the floor and walls is minimised. The steps will provide excellent dissipation of the energy in the water as it flows over each of the cascades. The stilling basin at the end of the spillway will generally contain 2 metres of water and the final cascade into it will dissipate most of the energy remaining in the water. Stone protection will be provided to protect the more erodible soils where spillway flows re enter the river.

The concrete crest structure will be about 10m high and will be contained within concrete side walls which provide the abutments to the overlying road bridge. Access across the 55m wide spillway channel for Scarp Road will be provided by a 2-lane, 10m wide, 3 span, reinforced concrete bridge deck with two intermediate pier supported on the underlying spillway crest structure.

The spillway excavation is expected to yield 174,000 cu.m of rockfill (bulked) for the dam construction.

4.5 Intake Tower

This will be a free standing, dry well tower, 57m in height, founded on fresh rock at about RL 167, some 8m below natural surface level. The tower design will allow for slip form construction in reinforced concrete. The intake system will comprise 5 screened intakes at different levels to permit selective withdrawal from the reservoir. All intakes will connect to a common 1400mm dia. riser and outlet pipe.

The tower will include a hoist house, complete with circular crane to permit removal of valves from the tower or lifting of intake screens for cleaning and repair. Vehicular access to the hoist house will be provided by an 80m single span steel space truss bridge structure.

4.6 Outlet Works

The main outlet pipe from the new dam will connect onto the existing 915 mm diameter gravity pipeline from the pipehead dam. The outlet will be constructed in 1400 mm diameter pipe, including the intake tower riser and 5 intakes, capable of delivering up to 450 Ml/d. In addition, the outlet culvert has been designed to have sufficient capacity to allow river flows to be diverted through it during construction of the embankment.

At a valve chamber below the main dam, a branch off the outlet pipe will permit scour discharges and water releases into the existing pipehead dam, from where they will flow into the downstream water course. A vertical discharge valve will be used to dissipate energy before allowing the water releases to enter North Dandalup River. Flow metering will be required of both water supply to Metro system and of the discharges into the stream course.

4.7 Water Treatment Plant

The water treatment plant and buildings will be similar to those of the recently completed and similarly rated Harris Dam, incorporating fluoridation using fluorosilicic acid and disinfection by chlorination using chlorine gas. The existing water treatment building is in poor structural condition due to expansive foundation soils causing movement and cracking of the building. The re-use of this building for the longer term is not a realistic and a new facility is required.

The location of the new building has been subject to a HAZOP study to determine the interaction between the building functions and other uses of the area. The location selected will be such that the risks associated with other alternative uses of the area, such as public access, are within accepted levels.

4.8 Reservoir Clearing

Forest within the proposed reservoir basin, an area of about 505 ha, will be cleared prior to the first filling of the dam. Useable timber products will be removed by CALM, possibly with the assistance of the main contractor. Clearing will only take place up to full supply level (RL 219m). Locally, in the stream channels at the top end of the reservoir where streamline vegetation predominates, clearing will be kept below RL 217m.

The removal of forest products will not commence until the EMP is approved. This work, and associated clearing for site establishment will be strictly controlled until the pipehead dam is decommissioned in Oct 1992. Clearing in the summer of 1992/93 will probably be limited to the borrow areas, quarry site, gravel pits and the embankment locations. The main reservoir clearing will not take place until the 1993/94 summer.

All material which is not removed as part of the process of salvaging forest produce will be stockpiled in windrows and burnt. Burning will conform to all the requirements of the Bushfires and the CALM Acts.

4.9 Existing Pipehead and Other Facilities

The existing pipehead dam is a six metre high, concrete gravity structure, which will be largely retained as a small public amenity lake. The associated screening chamber building will be removed and the screening chamber filled to provide a viewing area or similarly landscaped.

The existing 915mm dia. gravity main which is fed by the pipehead and discharges into the 1065mm dia. pipeline from South Dandalup, will continue to be used to deliver water from the new dam into the metropolitan water supply system. No additional trunk main will be required as part of this

project. The existing Ranger's house on the left abutment will be replaced as it lies within the foundation area of the new dam embankment.

Only minor upgrading of existing power supplies are envisaged for the permanent works. This will probably involve little more than installation of a new pole transformer and local reinforcement of power lines. Power requirements for construction are likely to produce a relatively heavy demand and these will be met by mobile diesel generators.

4.10 Site Restoration and Public Amenity Areas

The Water Authority is developing an integrated landscape and rehabilitation plan for the project area. A preliminary concept plan has been prepared and is forming the basis for the project design (Figure 7 & cover). The concept incorporates limited public access and recreational use, minimising the problems of controlling the unauthorised use of the catchment and reservoir. These have the potential to put water quality in the reservoir at risk.

The existing pipehead reservoir will be retained as a central feature of the area downstream of the dam. As discussed earlier the facilities will be modified to take the maximum advantage of the lake formed by the pipehead. The lake will generally be kept full by seepage from the main dam and by water releases for downstream purposes which will be released into the lake.

The lake behind the pipehead dam and the spillway cut will form natural barrier's to vehicle access to the nature reserve downstream of the dam. The only other access into the area is by the Water Authority's pipeline access road which is restricted by a locked boom gate at the river crossing. Access by walking would still be possible and would not be discouraged. These proposals should minimise the risk of any adverse impact on the conservation value of the nature reserve downstream of the dam.

The surrounding area will include a parking zone, toilets and grassed area for picnics and informal recreation. Access will be by the normal Water Authority access road. The landscaping will incorporate native shrub plantings, established with irrigation, to formalise the various areas.

The rerouted Scarp road offers a number of pleasant vistas over the lake and surrounding country. Stopping points and pull off bays will be provided at selected points along the way, including notice boards and rubbish disposal facilities.

Rehabilitation prescriptions will be prepared for all areas to be disturbed by the project. These will be similar in form to those used on the Harris and New Victoria dam projects and will incorporate the following features;

(i) use of topsoil from selected locations within the reservoir basin for spreading over the disturbed areas
(ii) terracing cut slopes to retain the topsoil
(iii) hydro mulching cut and fill slopes, using native seed mixes and fertilizer to enhance plant growth
(iv) incorporating a cover crop such as cereal rye to stabilise steeper areas until the native species develop
(v) deep ripping and sowing native seed mixes on the flatter areas
(vi) selecting seed mixes from the local species known from the area.
(vii) landscape areas will incorporate native plants with known horticultural viability, but arrangements will be made to incorporate some local species within the plantings.

5 ROAD CONSTRUCTION

5.1 Hines Road Upgrading

The Stage 1 ERMP acknowledged that the existing access to the site would need upgrading before construction activities commence. In particular Hines Road is to be upgraded to a 2-lane bitumen surfaced road (70kph design speed) through to Scarp Road. The Shire of Murray will be undertaking the planning and construction of this work on behalf of the Water Authority.

In several places the road upgrade will deviate from the existing alignment. The turn off from the South west Highway onto Hines Road and the section past the primary school will be upgraded. This will provide a better access to the school and a safer intersection with the highway.

Discussions will be held with the school authorities to arrange for satisfactory traffic control during school hours. The radius of several bends on Hines Road will also require increasing to meet the higher road standard. In these locations some clearing of road-side vegetation will be necessary.

No significant vegetation was noted in these areas during preceding studies. However the Water Authority will arrange an inspection of proposed deviations to assess any significant impacts on vegetation and to recommend any requirements for mitigation.

5.2 Scarp Road Rerouting

Scarp road, the major north-south link road, will be inundated locally by the reservoir. A new alignment has been selected upslope of the reservoir and running over the top of the main embankment and the saddle dams as a 2-lane surfaced road.

During construction Scarp will remain open for public use, although it will also be used by the Contractor and other people engaged on construction activities. Where construction traffic crosses Scarp Road, such as earth and rock hauling equipment, a controlled crossing will be installed, incorporating either traffic and grade separation, signals or some other form of regulation.

Relocation of Scarp Road west of the new reservoir will push the road up onto the steeper slopes and into the interface between the Helena and Scarp vegetation complexes. These slopes are erosion prone, dieback free and support floristically and structurally diverse vegetation.

Erosion control will be given particular attention in establishing this road. Care will also be given to ensuring that dieback free materials and appropriate construction practices are used in road construction so as not to introduce dieback high in the landscape. The road will be located so as to minimise direct impact on vegetation, whilst not unduly compromising water quality within the reservoir.

In principle the road will be located close to the reservoir in order to keep the road as far east as possible, thereby minimising intrusion into the Scarp landform, while at the same time maintaining a natural vegetation buffer between the reservoir and the road. The landscape planning will identify opportunities for the construction of viewing areas and lookouts off this section of road.

5.3 Sharp and Other Forest Roads

Upgrading of Sharp Road by Alcoa and other forestry roads by CALM has been undertaken recognising the future reservoir water levels and Water Authority conditions for catchment management. The Water Authority will continue to liaise closely with Alcoa and CALM on roads and other aspects of catchment management (see section 10).

6. SOURCES OF CONSTRUCTION MATERIALS

6.1 Quantities Required

Quantities of fill required 'in bank' for all 3 dams, are 1,107,000 cu.m earthfill, 953,000 cu.m rockfill and 140,000 cu.m of filter materials. The earthfill will be taken from borrow pits to be developed within the reservoir basin, within 2 km of the dam embankment(s). Similarly rockfill will be generated from the spillway excavation, with the balance coming from a quarry to be developed within the reservoir basin, at a distance of 1.5kms from the dam embankments. Sand and gravel for filters and transition zones are likely to be fully processed materials, imported locally from commercial quarries. The location of the various borrow materials are shown on Figure 8.

6.2 Forest Hygiene

In general most of the fill materials obtained from within the reservoir will be hauled to the locations in which they are to be placed using haul roads located within the reservoir basin.

CALM dieback control prescriptions will be applied to plant coming to and leaving the site. This is discussed in more detail in Section 9.2.

Gravel materials from the borrow areas at the upper end of the reservoir may possibly be hauled along Sharp road which has recently been upgraded by CALM and ALCOA. The use of Sharp Road for these purposes will be carried out in accordance with guidelines set by CALM. Generally this work will be carried out during the summer and transport during periods of rain will be avoided. If this is not possible use would be made of haul roads within the reservoir basin.

7. MANAGEMENT OF IMPACTS ON RESERVE C21038

7.1 Proposal For Modification Of Boundary

The existing pipehead dam and the first 7km of the existing pipeline and access track are located within the boundary of Reserve C21038 which was originally gazetted as a public reserve for Parkland and Recreation. This Reserve has been the subject of a System 6 Redbook recommendation that the purpose be amended to Conservation of Flora and Fauna under a form of joint vesting.

The North Dandalup Dam project will increase the area of Water Authority works which would be located within the reserve as shown on figure 9. The ERMP Stage 1, indicated that the impact of excising this land from the reserve would not critically compromise its viability for conservation. The area of the excision proposed (figure 9) covers the proposed locations of the spillway and embankment and includes the route for the existing pipeline and maintenance access track.

7.2 Public Access

Condition 3(ii) of the EPA's conditions of approval of the Stage 1 ERMP highlighted the need to consider the management of public access to the remaining portions of the reserve. Some concern was held that increased public usage of the area around the dam could lead to deterioration of the condition of the reserve.

As discussed in Section 4.10 the Water Authority proposes to develop a small scale, informal public amenity area around the reservoir to be left behind the existing pipehead dam. By providing a focus for public recreation, the Water Authority believes that misuse of the areas around the dam and the reserve can be minimised.

The existing access into the reserve off Hines road will not be affected by the project. The only road access downstream of the works and the public amenity area will be along the pipeline access track. This track will be closed off with a locked gate to prevent vehicle access to the downstream area. Access by walking would still be possible. Off road access down the left bank of the river will be very effectively cut off by the spillway excavation and should not present a problem. The river bed and the lake behind the existing pipehead reservoir will limit any access to the right bank of the stream.

7.3 Spillway Design

As outlined in Section 4.4, the design of the spillway with the stepped chute and stilling basin will very effectively dissipate most of the energy in the water flowing downstream. No significant disturbance to the streamline or surrounding vegetation due to high energy water would be expected with this form of design. The stilling basin will be very similar in design to that at the recently completed Harris and Harding Dams. The latter has flowed on two occasions and has performed very satisfactorily.

7.4 Pipeline and Maintenance Access Road

The outline of the proposed excision of a reserve over the existing pipeline and maintenance access road have been surveyed and marked on the ground. These marks follow the outline of the area that is already disturbed by the existing works and no increased disturbance is expected to occur due to the project. The vegetation transects that have been established will be used to monitor impacts on the surrounding areas of the reserve.

7.5 Rehabilitation of Pipehead Dam Site

As already discussed the existing pipehead dam and reservoir will be largely retained to provide a central focus for the downstream recreation area. The main works which will be undertaken will be the removal of the existing screening chamber and filling of the area. The water level in the lake will remain substantially unchanged although there may some reshaping of the banks to improve access locally. Landscaping will be used to maintain and improve the aesthetic values of the area.

7.6 Monitoring and Plan Modification

As has already been noted in section 3.4 and as further detailed in section 11, a monitoring programme is being established to determine any changes which might take place during the development and operation of the project. This programme, together with the results of any on site observations by the Ranger, will be used as the basis of developing any modifications to the programme which may

become necessary. Such modifications to the programme will be discussed with CALM and the EPA before they are implemented.

8. WATER RELEASE STRATEGY

8.1 Confirmation of Water Authority Undertakings

As result of representations to the Minister for Water Resources regarding the perceived impact that the North Dandalup project would have on the Peel - Harvey estuary, the Water Authority made certain undertakings in respect to supplementing downstream river flows. These undertakings are twofold and will ensure that on average there is no net reduction in water flows to the Peel - Harvey Estuary. The first is in relation to supplementation of flows through the Harvey River. The second is in relation to downstream releases from the North Dandalup Dam.

Supplementing flows into the Harvey Estuary

The proposed North Dandalup Dam and associated Conjurunup pipe-head will reduce the average annual inflow to the Peel Harvey Estuary. The Water Authority undertakes, to discharge an equivalent amount of water from the Harvey River diversion back into the Harvey River and consequently to the Estuary.

The discharge will be managed so that drainage for farmers downstream is not adversely affected. The discharge will begin with development of North Dandalup Dam and be closely monitored in conjunction with the Waterways Commission.

Independent assessments of the impacts of the releases will be arranged and provided to the Minister for Water Resources and Minister for the Environment. The implementation of this undertaking to divert water will need approval of the Minister for the Environment.

Releases from the North Dandalup Reservoir

The Authority undertakes to make annual releases through the dam in summer months from December to March. These releases will be in quantities typical of summer flows over the last 15 years and will be additional to any overflows during winter months.

The following sections outline the specific actions to be undertaken to meet the above undertakings.

8.2 Releases to North Dandalup River

The requirement for releases to the North Dandalup river as required under commitment 11 of the EPA Conditions of Approval overlap with the undertakings given by the Water Authority to the Minister for Water Resources in the

forgoing paragraphs. The releases will be made through the vertical cone discharge valve into the lake behind the pipehead reservoir and will flow over the pipehead dam into the streamline downstream of the dam.

The volume of these releases on a monthly basis will be as follows (Table 8.1);

Table 8.1 Monthly summer releases to the North Dandalup River

Month	December	January	February	March	Total
Monthly Release m^3x10^3	215	82	15	14	326

The releases would be made at a relatively uniform rate and in such a manner as will ensure that flow rates are maintained immediately downstream of the pipehead dam. While the total volume of releases is regarded as relatively fixed by the above table there would be some scope to vary the distribution between the months and also within the months. Further discussion will be held with the local North Dandalup surface water advisory committee to determine whether any modification is necassary.

8.3 Releases to Harvey River System

The proposal to release water from the Harvey River Diversion back into the Peel Harvey estuary will be the subject of a separate referral to the EPA. This referral will outline in more detail the details of the proposal, its likely impact and the monitoring programme proposed. The diversion of the flows back into the Harvey River can be achieved fairly easily by opening the penstocks on the existing structure. The aim will be to release on average 13 million cubic metres of water per annum through the structure.

Water flows will be monitored at the diversion structure and downstream of the penstock on the Harvey River. A trial release programme will probably be included to check out any problems which may occur. Control of the flow through the structure can be maintained by adjusting the opening of the penstock and can be adjusted to minimise any adverse flooding impacts on the farming communities downstream.

Details of the monitoring programme for the Peel Harvey estuary will be developed in consultation with the appropriate authorities.

9. FOREST MANAGEMENT

9.1 Coordination

Coordination of joint Water Authority/CALM activities in this region is normally between the Regional Planning Officer at CALM's Northern Forest Regional Headquarters at Kelmscott and the Water Authority's Supervising Engineer Dam Operations. This coordination process usually involves other catchment management staff from the Water Authority and officers from the various CALM districts.

On the North Dandalup project the same formal lines of communication will be maintained. However, staff from the Water Authority's project management team will be closely involved in the detailed planning and construction phases. During the construction phases of the project the responsibility for the day to day operations will be handled by the Water Authority's construction management group and the Regional Officers from CALM.

9.2 Access Management and Dieback Control

The control of access on and around the site and hygiene restrictions to control the spread of dieback disease will be carried out in accordance with CALM reference manuals and instructions. Within the area of the works and the reservoir basin, to which the Contractor's operations will be strictly confined, there is expected to be limited impact on construction operations. The primary access to the site will be via Hines and Scarp roads which both have good quality pavements, the former being sealed for the project, and have good drainage.

The main areas where stricter controls will be required will be where dieback free materials are sourced from within the reservoir basin for use outside the project. This is expected to apply mainly to the use of gravel material for road construction by the Shire and others. Dieback free gravels are in strong demand and no problems are expected in using this material. The demand is not so strong for dieback infected material, although every attempt will be made to use all the gravel material from the reservoir basin.

CALM will carry out dieback mapping over the area of the works and the reservoir basin during the 1992 winter. This mapping will be used to delineate dieback free areas within which specified resources exist. Those resources which are surplus to project requirements will be made available to other users. Areas of dieback free materials within this category will be excluded from the areas to which the Water Authority's contractor will be permitted access. CALM and the Shire will then control the extraction of those resources which are surplus to project requirements.

Access to the resources within the reservoir basin will be by means of roads to be constructed by the Water Authority to CALM specifications. These roads will be used for

carting out forest products and for the hauling of dieback infected basin resources from the reservoir basin. These haul roads will probably be upgraded from existing tracks, leading up the two main arms of the reservoir from Scarp Road. Dieback free materials will be removed using existing higher level roads such as Sharp and North Roads.

9.3 Timber Resource

The main timber resource which will be available from the reservoir basin includes about 5000 m^3 of second grade sawlog, specification firewood, jarrah poles and mining timbers. CALM will be responsible for the salvage of the timber resource, either using their own resources or by contracting the work out. In areas to be clear felled there will be some non commercial firewood product available for salvage. Most of the logging operations will be carried out during the winter period to minimise disruption to CALM's other logging and forest management operations, with product hauled out during the following summer months.

The areas from which the timber resource will be harvested as a result of the project works include the reservoir basin and area of the works which will be largely clear felled as outlined in section 4.8. The product from the area of the works and borrow pits will be logged in the 1992 winter, with the balance of the reservoir logged during the 1993 winter.

The North Dandalup pipehead dam will be used to supply water during the 1992 winter, up until the end of October. Logging operations will have to be conducted in accordance with the guidelines for operations on water supply catchments in order to minimise water quality problems in the water supply.

In addition, CALM propose harvesting some of the sawlog and other product from the area immediately above full supply level, over a width of possibly 500 metres. This process is designed to minimise any disturbance which logging operations might cause when the reservoir is operating and will probably be carried out during the 1992 winter. To aid identification of the full supply level the Water Authority will bulldoze a track on the contour.

The formalised salvage of non commercial firewood from the reservoir basin has not generally been carried out on past reservoir projects. By definition this material is not a commercial proposition for harvesting as it is generally green wood, often in small sizes and requires storage for a considerable period of time before it is dry enough to burn.

The Main Roads Department have regularly held open days for public firewood collecting on their freeway projects. Other possibilities include salvage and storage by the Water Authority's clearing contractor or by a separate firewood salvage contract. While the sale of the firewood will

probably cover the costs of salvage and storage, the work incurs some financing costs which have to borne up front.

In the the case of New Victoria Dam, the Water Authority agreed to provide a fund to finance the salvage work by CALM and a location for storage of the firewood. The proceeds of sales of firewood over the next summer or two will be used to pay back monies advanced for the salvage operations.

This is the preferred method of operation for the North Dandalup project. CALM will advise the size of the advance they require to finance the salvage work which will be carried out just prior to clearing during the 1993/94 summer. The Water Authority will make available a suitable area of its land on Sharp road for temporary storage and CALM will refund the cash advance from the proceeds of the firewood sales.

9.4 Gravel Resources

The objective for the project is to maximise the extraction of the useable gravel resources during the course of construction. As noted earlier dieback free gravels are in strong demand and it is expected that materials which are surplus to project requirements can be utilised elsewhere in the district. CALM, MRD and the Shire have expressed strong interest in using these gravels.

There are a number of steps which have to be gone through to determine the amounts of material available and how they can be accessed. The Water Authority has completed an inventory of the quantities of gravels available in the basin. The next step in the process is for CALM to complete the dieback mapping and for the Water Authority to determine the quantities of materials required for the project. Surplus materials would then be available for use elsewhere. Priority will be given to making dieback free materials available for use off site.

9.5 Brick Making Resources

Over the years a number of companies have expressed interest in using the clay resources of the basin for making bricks. More recently, information on the materials identified during the materials search programme has been forwarded to the various groups. However to date there has been no positive response from any of them. Discussion are proceeding with a view to making any surplus clay resources available to potential users.

10 LAND MATTERS

10.1 Land Affected

The main areas of land impacted by the project include some readjustment of road boundaries caused by the realignment of

curves associated with the upgrading of Hines road, the excision of some small portions of location 643 for the construction of the saddle dams and upgrading of Hines road and the readjustment of the boundaries of reserve C21038 as detailed earlier. The relocation of Scarp road and minor modifications to Sharp and Reynolds road take place in State Forest. No action on any of these matters will be undertaken until formal approval of the EMP has been given.

10.2 Catchment Management

The Water Authority has prepared broad guidelines for the management of the North Dandalup catchment (Moore 1988). The guidelines deal with two main areas of management, forest based and mining impacts. Mining activities, which include bauxite mining as well as gravel and clay quarries, have been discussed elsewhere in this document and will not be considered further in this section.

Forest activities include logging, forest leases, burning, firewood collection, FIRS programmes, rehabilitation, thinning, feral animal and weed control, road construction, flower/seed collection, bee keeping, experimental plots and recreation. The management guidelines give specific guidance for dealing with these issues to ensure that appropriate levels of water quality are maintained and the details will not be repeated in this document.

Of specific interest is the question of recreational activities on the catchment and reservoir. The Western Australian Water Resources Council has reviewed the policies on recreation on catchments and published guidelines based on their review (WAWRC 1985). These guidelines have been adopted as policy by the Water Authority.

Under this policy the catchment would change from being a class I, defined as one which serves a small reservoir which supplies domestic water that is diverted directly into the distribution system, to a class II catchment or one which serves a large reservoir supplying direct to the distribution system. For class II catchments, low intensity recreation such as bushwalking and nature study are considered acceptable. Under the WAWRC guidelines recreation on the water body, including wading, swimming, fishing and boating, would not be permitted.

10.3 Bauxite Mining

Alcoa's bauxite mining is expected to progressively move into the North Dandalup catchment over the next 10 years or so. The current plans show that in the latter part of the next five year plan, mining will move into the catchment, with the major mining effort stepping up in the following five years. Mining in these areas is carried out under the auspices of the Mining and Management Programme Liaison Group and includes representatives from the Water Authority and other State Government organisations.

Mining is carried out under strictly controlled conditions designed to minimise the risk of disturbance to water quality. These procedures have been successfully developed over many years during periods of mining on other water supply catchments such as Wungong and South Dandalup. The most recent upgrading of these procedures has been approved by the Water Authority and no changes are foreseen.

11. ENVIRONMENTAL MONITORING

11.1 Aquatic Fauna

Macroinvertebrates

Given the proximity of the North Dandalup Dam to the Scarp, and the already degraded nature of the River on the Swan Coastal Plain, there is a relatively small amount of the stream environment that will be adversely impacted by the dam. Also, this section already exhibits intermediate levels of disturbance due to the impact of the pipehead dam. This raises the question of how the dam should be managed.

The Aquatic Research Laboratory has recently released the findings of a study investigating biological energy flow in the lower North Dandalup River (ARL, 1991). The findings suggest that the productivity of the river can be controlled through the manipulation of stream water velocities. Medium velocities of between 5 and 20 cms/sec^{-1} induced algal growth and high levels of Net Community Productivity, and was correlated with a diverse and abundant macroinvertebrate fauna. In lower flow areas, settlement of organic particles occurred with low levels of NCP, and higher flows caused stream bed erosion, creating a virtual biological desert. Because of the higher productivity, a greater degree of in-situ processing of nutrients, in particular nitrogen, was found to occur. If this can be maximised it has implications for reducing nutrient input to the Peel-Harvey estuary. These results form the basis of a suggested management regime for the North Dandalup River, below the dam.

It is unrealistic to expect that the River can be managed such that pre-European conditions can be returned. However, it is considered important to manage the system so that further degradation does not occur, and that habitat for existing aquatic species is enhanced. This is further justified if, by manipulating the river ecosystem, the quality of another system can be aided. The study results suggest that macroinvertebrate communities will be enhanced if river velocities are maintained at certain levels, and that this will help maximise the processing of nutrient inputs from agricultural and other activities.

The sampling for the above research was undertaken during late summer, and at the time, over 50% of the river bed comprised the favoured habitat (referred to as stable habitat in the report). Therefore, existing summer stream flows appear to maximise the desired habitats. However, the greater winter stream flows are likely to result in a higher

proportion of the eroded habitat. This suggests that existing summer stream flows should be maintained, but that winter stream flows should be reduced.

Although the research indicates this relationship between macroinvertebrate fauna and stream velocity in summer, there is no guarantee that it holds for winter, when productivity is altered due to climatic factors. The Authority is proposing to undertake a similar study this winter (1991) to determine this.

Relating near-bed water velocities to stream flow at the Dam is complex, in part due to the interaction between the river and groundwater on the Swan Coastal Plain. Changes in channel morphology will also lead to varying river velocities in different sections of the River. The Authority is currently developing a monitoring system that will enable discharge rates from the reservoir to be related to stream velocities. This will likely include a set of piezometers at a selected location, installation of gauging stations at several sites and monitoring of stream velocities on a regular basis. This will enable the Authority to determine the amount a water that should be released from the reservoir throughout the year.

Given that current summer stream flows appear to maximise the habitat, the strategy involve releasing the average summer stream flow from the reservoir. Catchment below the reservoir may result in adequate stream flows during winter, enabling all winter flows above the reservoir to be diverted for public water supplies. The combination of the further in-stream biological studies and monitoring of physical parameters, should provide sufficient information on which a decision can be made on the suggested downstream release strategy. The Authority will keep the EPA informed of the progress of these studies, and will consult with it prior to the implementation of any strategy.

Fish

Very little is known about the life-cycles and habitat requirement of the fish species indigenous to the Swan Coastal Plain. It is therefore difficult to predict what impacts manipulation of water flows will have on the fish present in the lower North Dandalup River. However, this section of the river is already significantly degraded, and the presence of all but one of the indigenous fish species suggests that they may have adapted to these conditions. In determining the downstream release strategy, the Water Authority will discuss the implications for these fish species with research staff at the University of WA and Murdoch University, as well as the EPA.

While lower flows may create more suitable conditions for mosquitofish, doubt has now been raised on the impact that this species has on native fish, and they may not be effected (Pen and Potter, 1991).

11.2 Vegetation

A series of four permanent transects have been established by Havel Land Consultants to permit monitoring of vegetation response to the project.

Two transects are located in the headwaters of the future reservoir: one on Foster Brook near Sharp Road and the second on the North Dandalup River near the intersection of North and Reynolds Roads. Two transects are located downstream of the proposed dam and spillway within the reserve C21038.

Baseline descriptions of the vegetation along these transects will be compared with observations in future years during scheme operation. Observations of vegetation in the intermittently inundated headwaters will provide a guide to the need for clearing and the types and extent of vegetation which should be retained within the basins of future reservoirs. Any changes in adjacent non-inundated vegetation are also important to note, not only in terms of vegetation protection but also because these areas are important resources for the fauna generally associated with the dense streamline vegetation habitat (see section 3.4).

Observations downstream of the project will confirm the prediction that scheme operation will not have a significant impact on the phreatic and aquatic vegetation of the Helena landform.

The conceptual monitoring programme involves a second survey of the established permanent transects prior to reservoir clearing, the third survey post clearing but prior to inundation and and the fourth survey following reservoir filling.

11.3 Terrestrial Vertebrate Monitoring

Prediction of the impacts that establishment of North Dandalup Dam would have upon the vertebrate fauna was constrained by the limited information available on previous dam projects.

As a means of documenting the impact associated with the North Dandalup and to permit more confident predictions of future impacts, the Water Authority will implement a vertebrate fauna monitoring programme

Conceptually the programme will be designed to selectively assess the impacts on amphibians, birds, reptiles, small and medium size mammals. Survey locations will be chosen from sites within the reservoir basin prescribed for clearing, in the adjacent forest areas which might be indirectly impacted, across the headwaters of the reservoir where periodic inundation is experienced, upstream of the reservoir and downstream of the project within Reserve C21038.

Surveys will probably be conducted in late summer and in early spring over one or two years to establish the baseline, again following clearing of the reservoir and a further survey after the reservoir has filled. The details of the programme have yet to be determined but will be developed in consultation with CALM and the EPA.

11.4 Reserve C21038

The monitoring programme outlined in the previous sections includes vegetation and fauna monitoring to monitor the impact of the project on the reserve C21038. The results of this programme, together with visual observation by the resident ranger will be used to assess any impacts generated by the project.

11.5 Harvey Releases

As noted in section 8.3, the releases to the Peel Harvey estuary system will be the subject of a separate referral to the EPA. This referral will include proposals for the monitoring and control of the operation, together with provisions for reporting to the appropriate authorities.

11.6 Reporting

As has already been noted in section 3.4 and as further detailed in this section, the monitoring programme is being established to determine any changes which might take place during the development and operation of the project. This programme, together with the results of any on site observations by the Ranger and other officers, will be used as the basis of developing any modifications to the programme which may become necessary. Such modifications to the programme will be discussed with CALM, the EPA and other appropriate authorities before they are implemented.

However as a general undertaking, an update of progress with implementing the various aspects of the EMP will be made to the EPA on an annual basis, with a post construction report to be completed, including data, following the first six months of operation.

GLOSSARY

AHD	Australian Height Datum
FSL	Full Supply Level
MFL	Maximum Flood Level
NSL	Natural Surface Level

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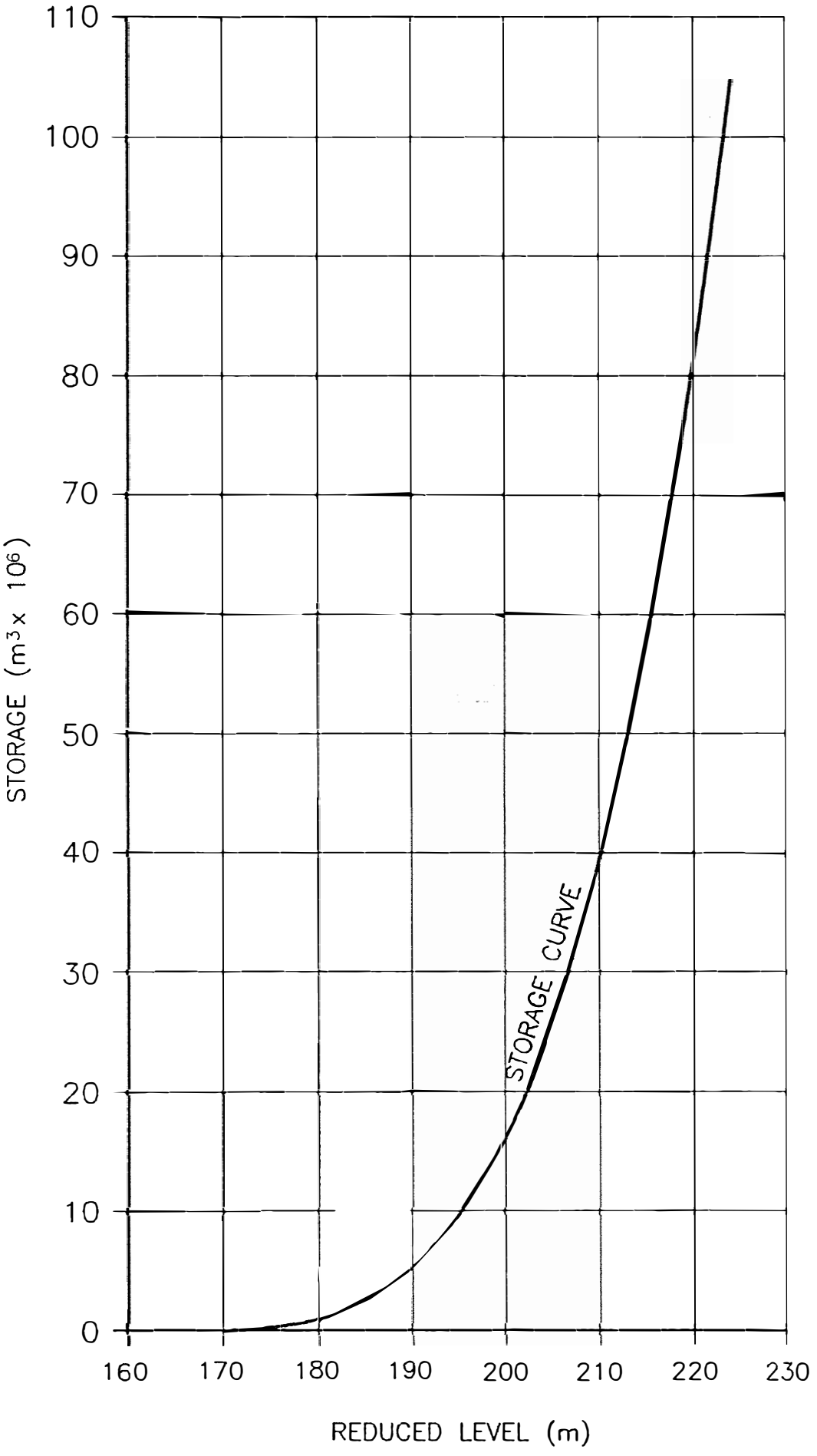
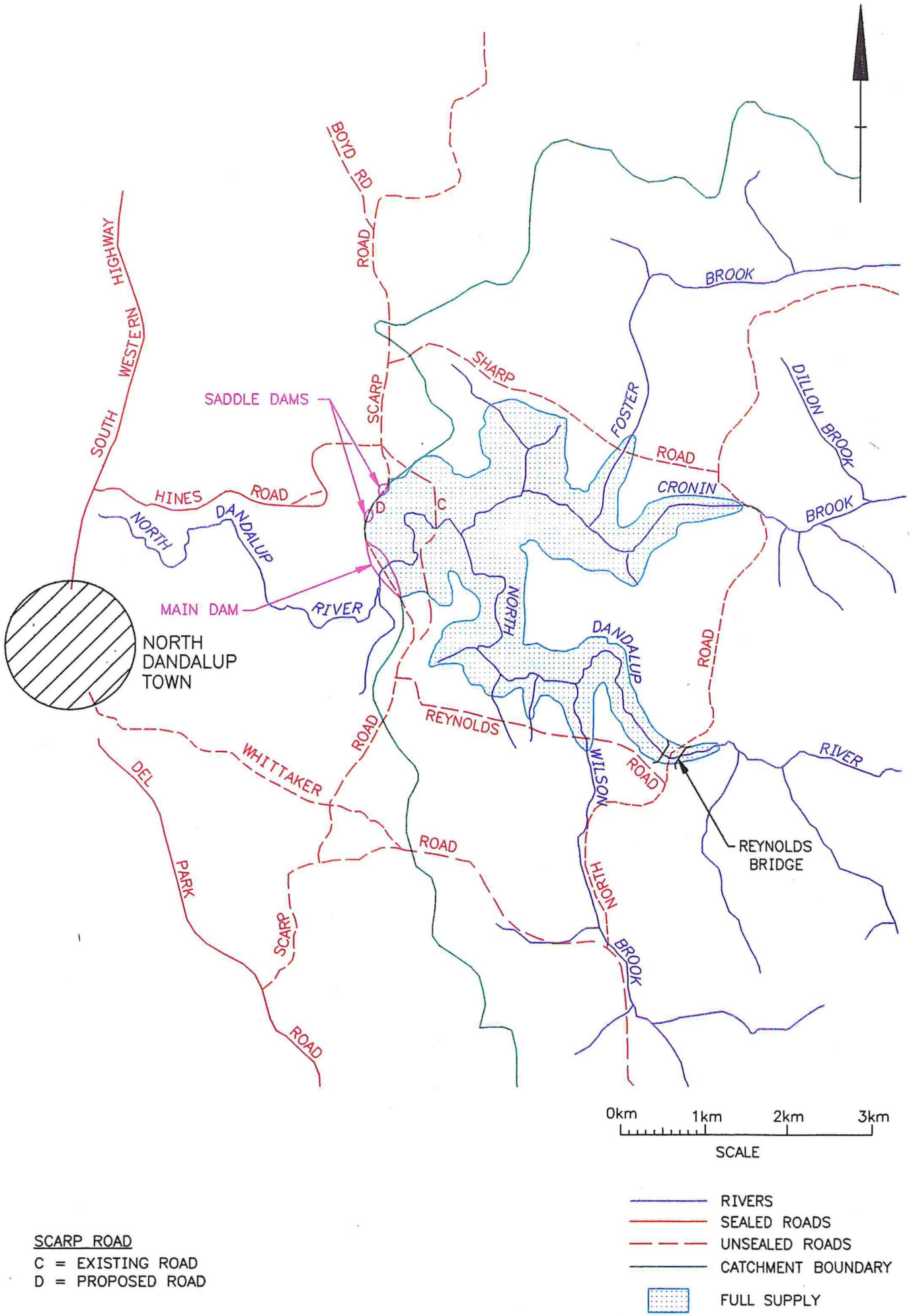
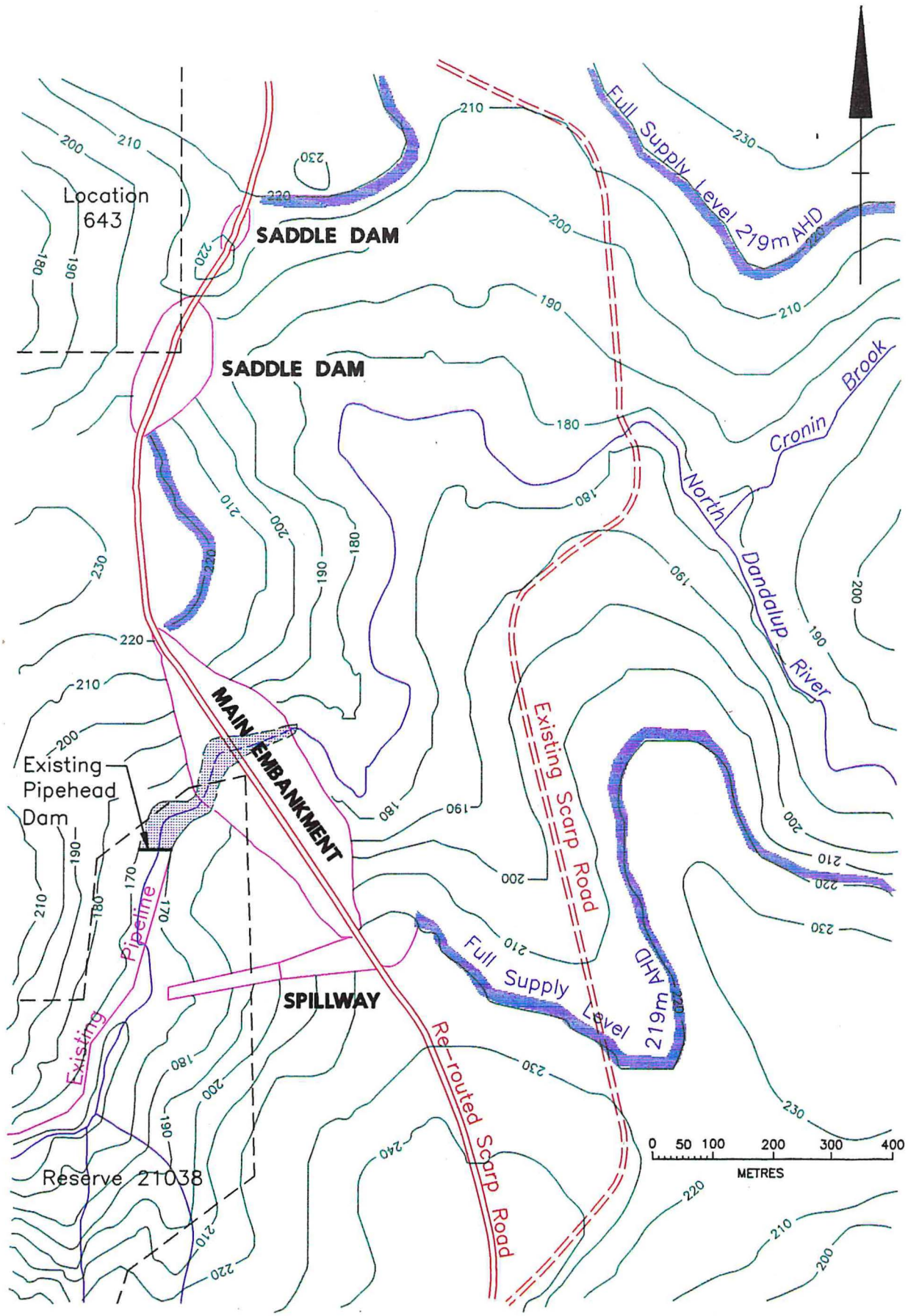


NORTH DANDALUP DAM



SCHEME LAYOUT PLAN

FIGURE 2



HEADWORKS LAYOUT PLAN

FIGURE 3

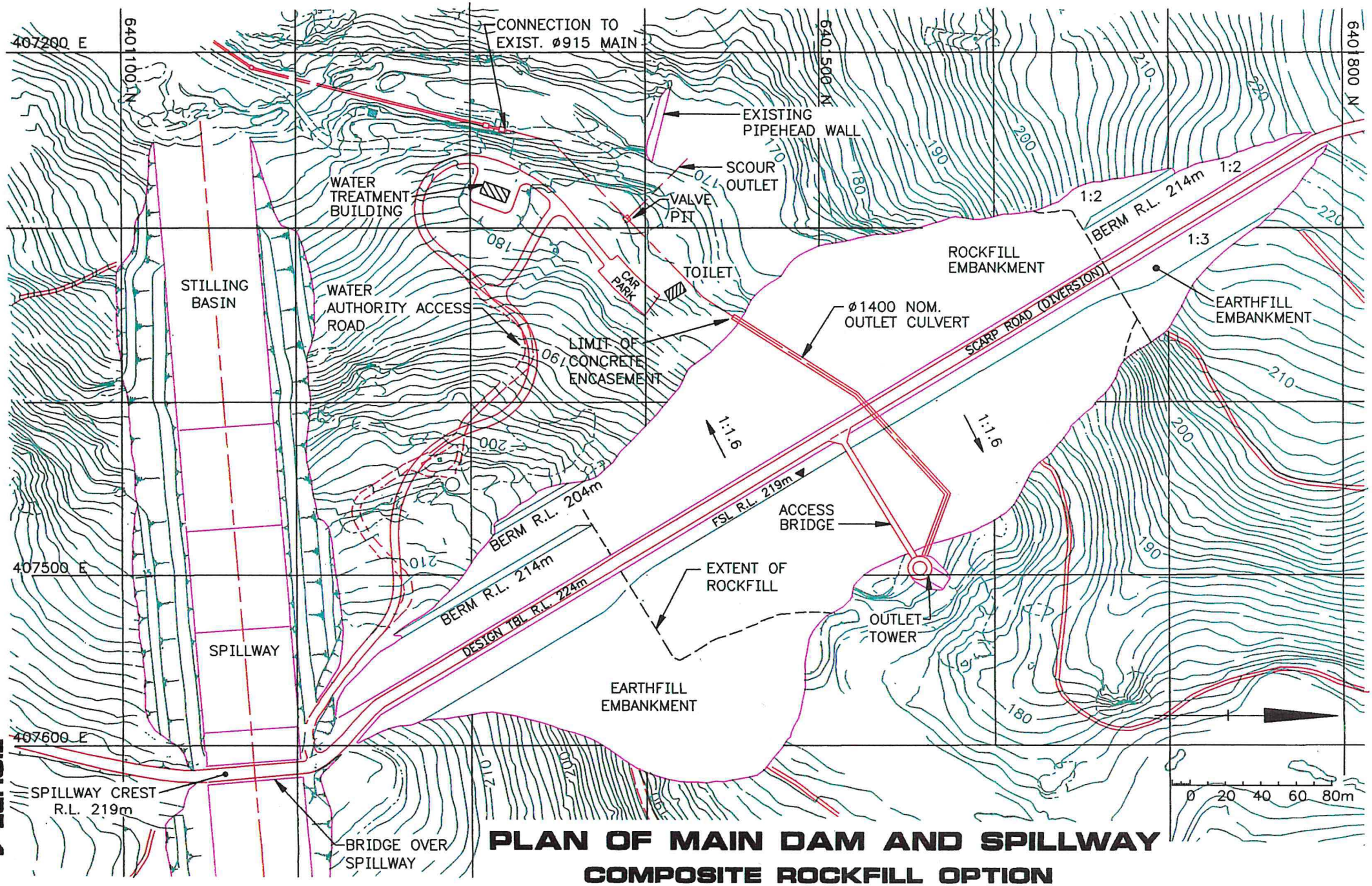
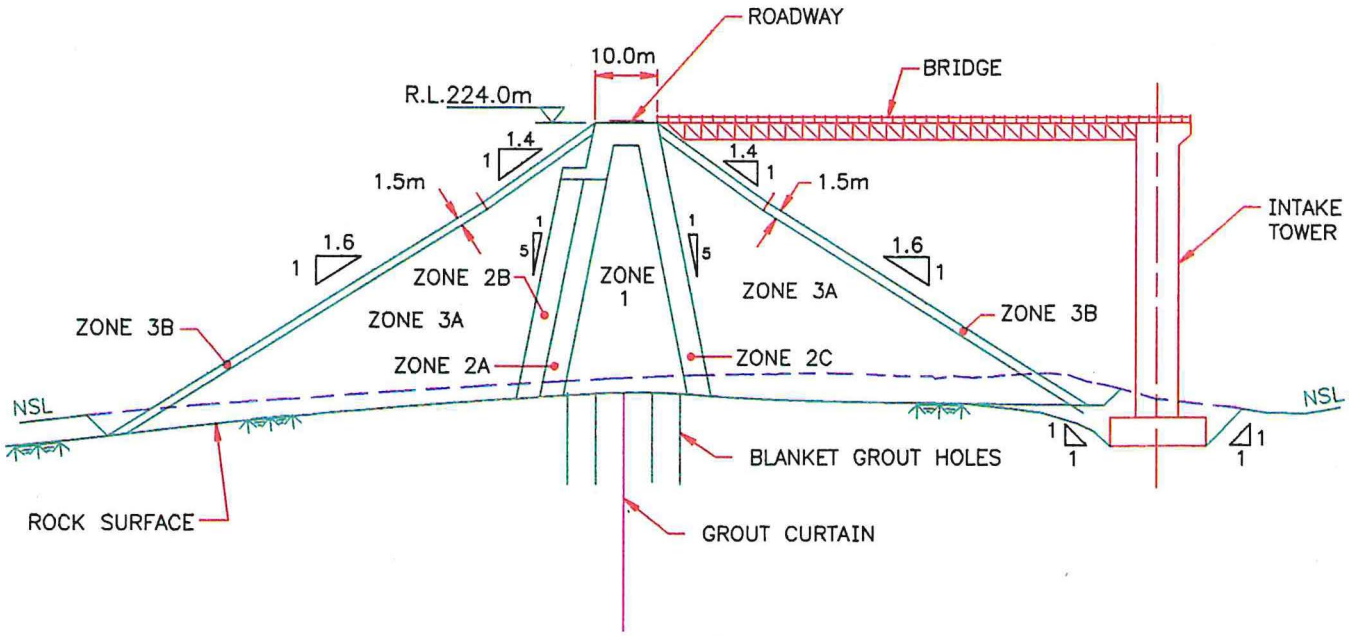


FIGURE 4

PLAN OF MAIN DAM AND SPILLWAY

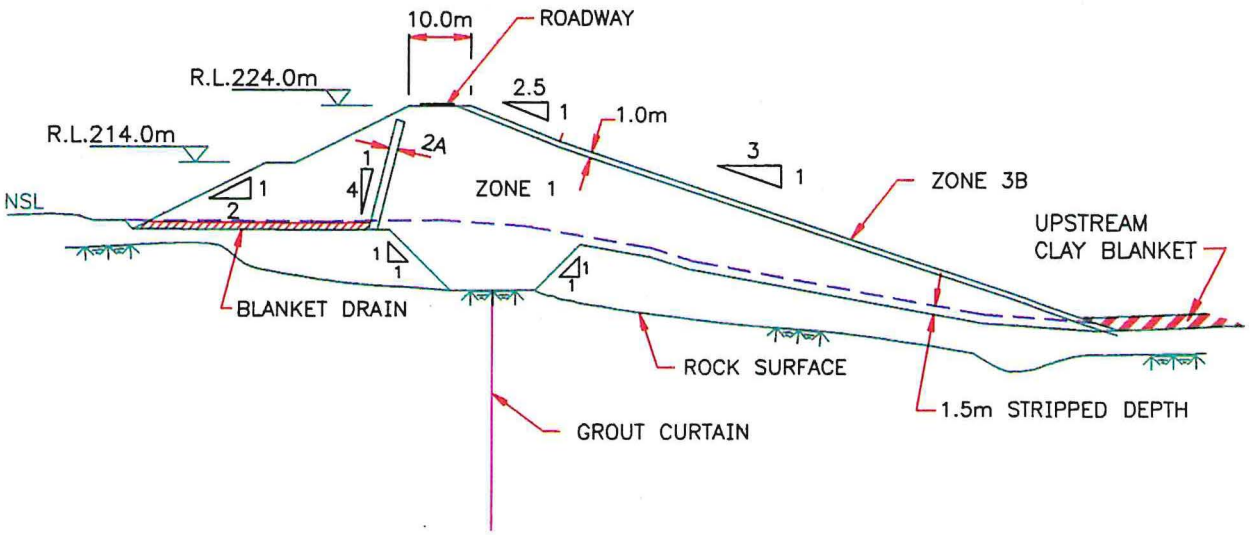
COMPOSITE ROCKFILL OPTION



CENTRAL ROCKFILL SECTION

KEY

ZONE		MATERIAL
1	—	EARTHFILL
2A	—	SAND
2B	—	GRAVEL
2C	—	TRANSITION
3A	—	ROCKFILL
3B	—	RIP RAP

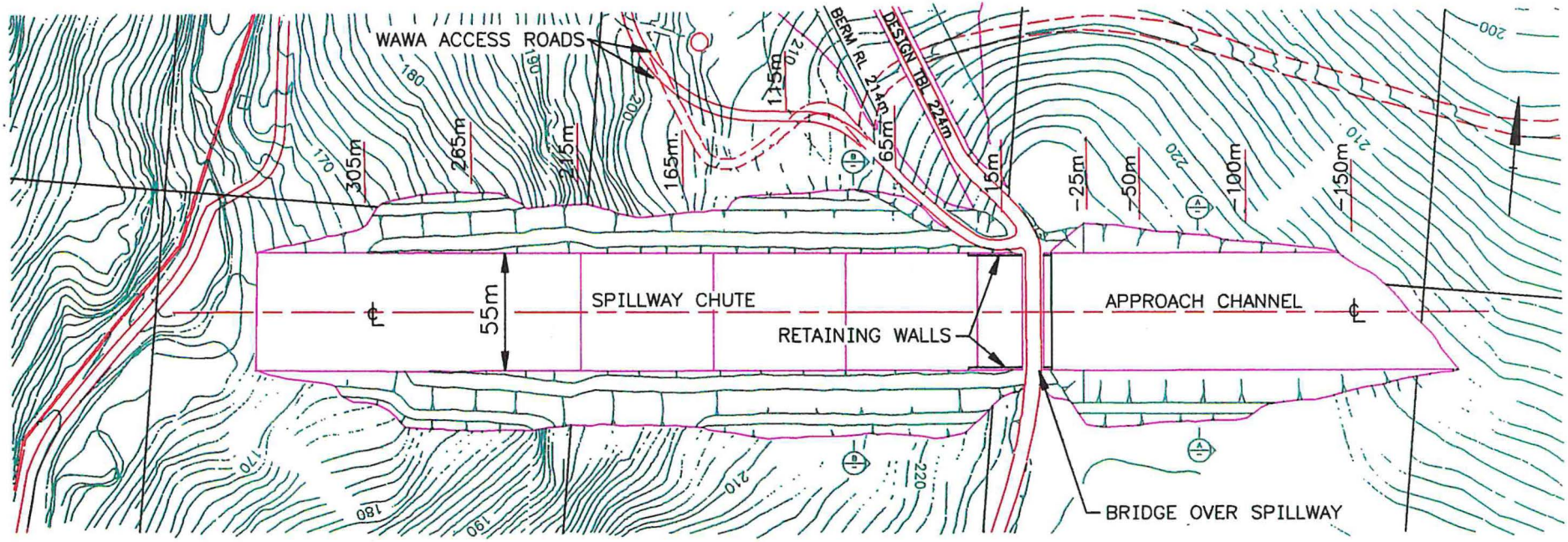


ABUTMENT EARTHFILL SECTION

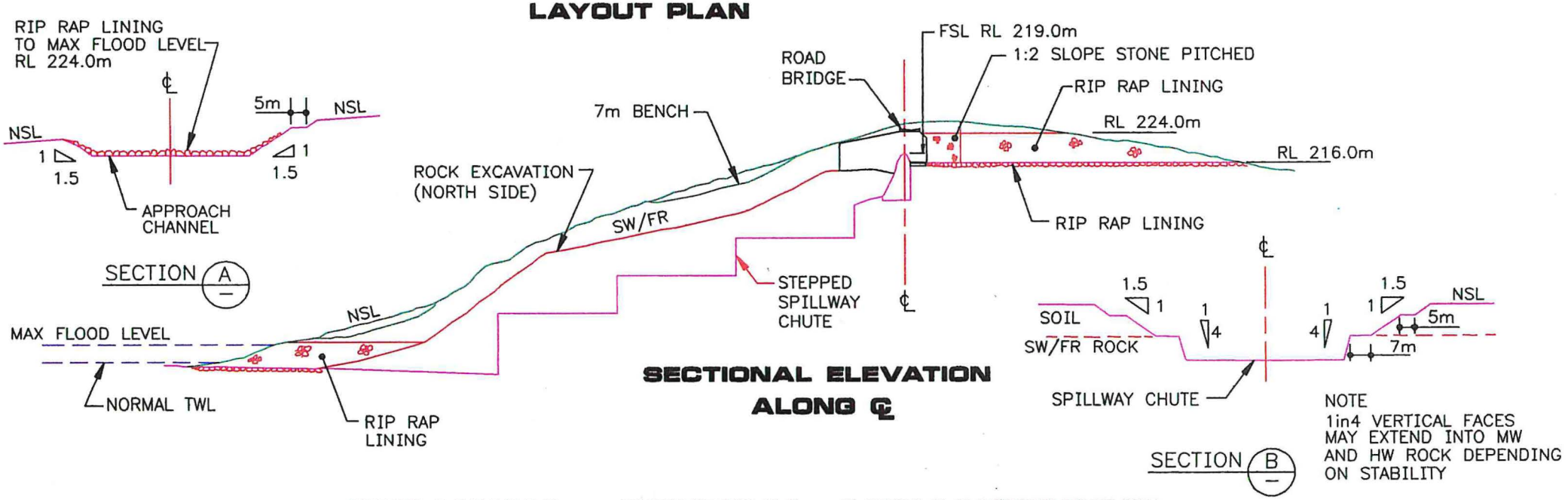
SADDLE DAMS SIMILAR THROUGHOUT

MAIN DAM CROSS SECTIONS

FIGURE 5



LAYOUT PLAN



SECTIONAL ELEVATION ALONG ℄

FIGURE 8

SPILLWAY - GENERAL ARRANGEMENT

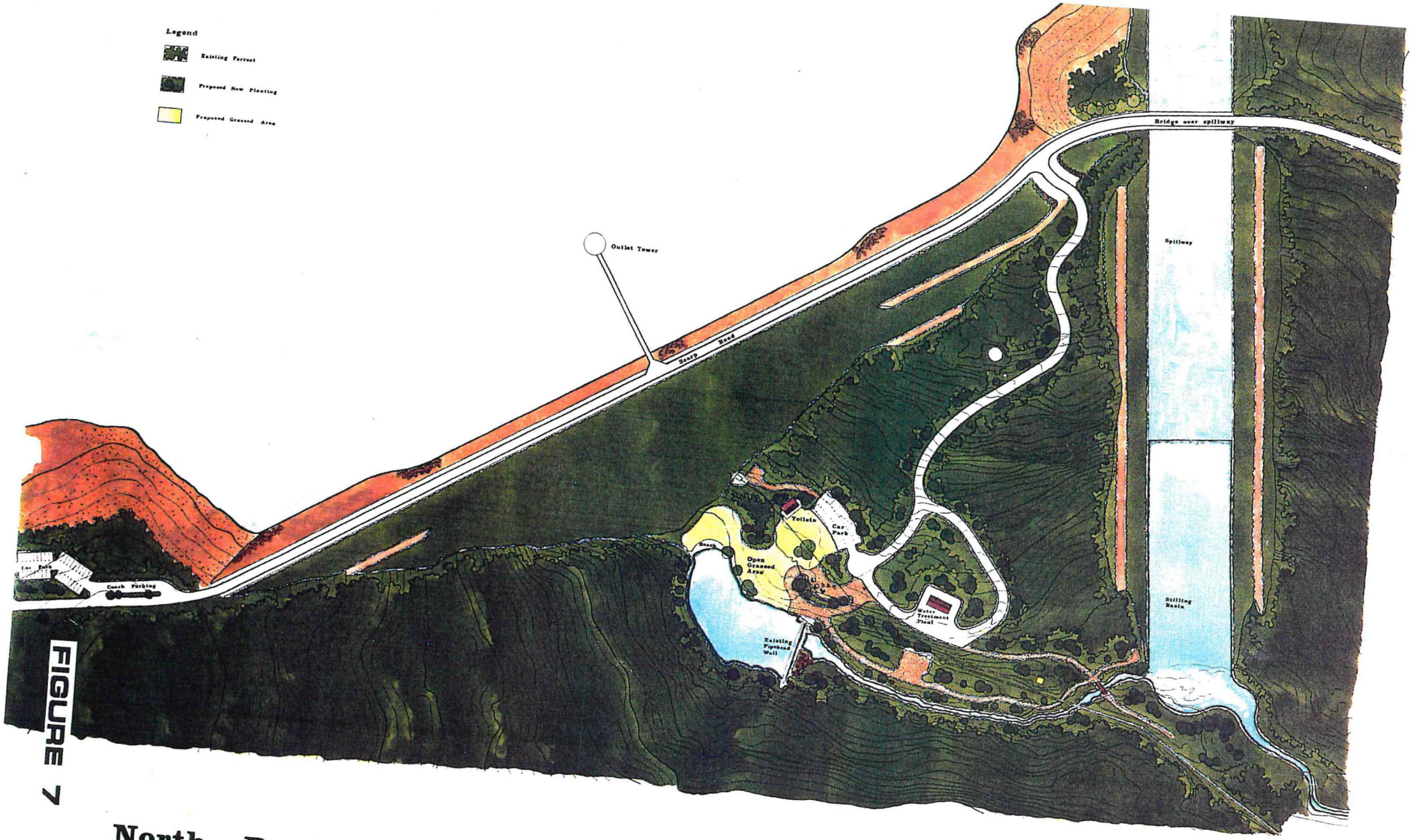


FIGURE 7

North Dandalup Dam

Conceptual Landscape Proposals

0 10 20 50 100

WATER AUTHORITY OF WESTERN AUSTRALIA

PETER CALA AND ASSOCIATES
LANDSCAPE ARCHITECTS & URBAN DESIGNERS
51 FORREST STREET, SUBIACO, W.A. 6008. (08) 381 4443

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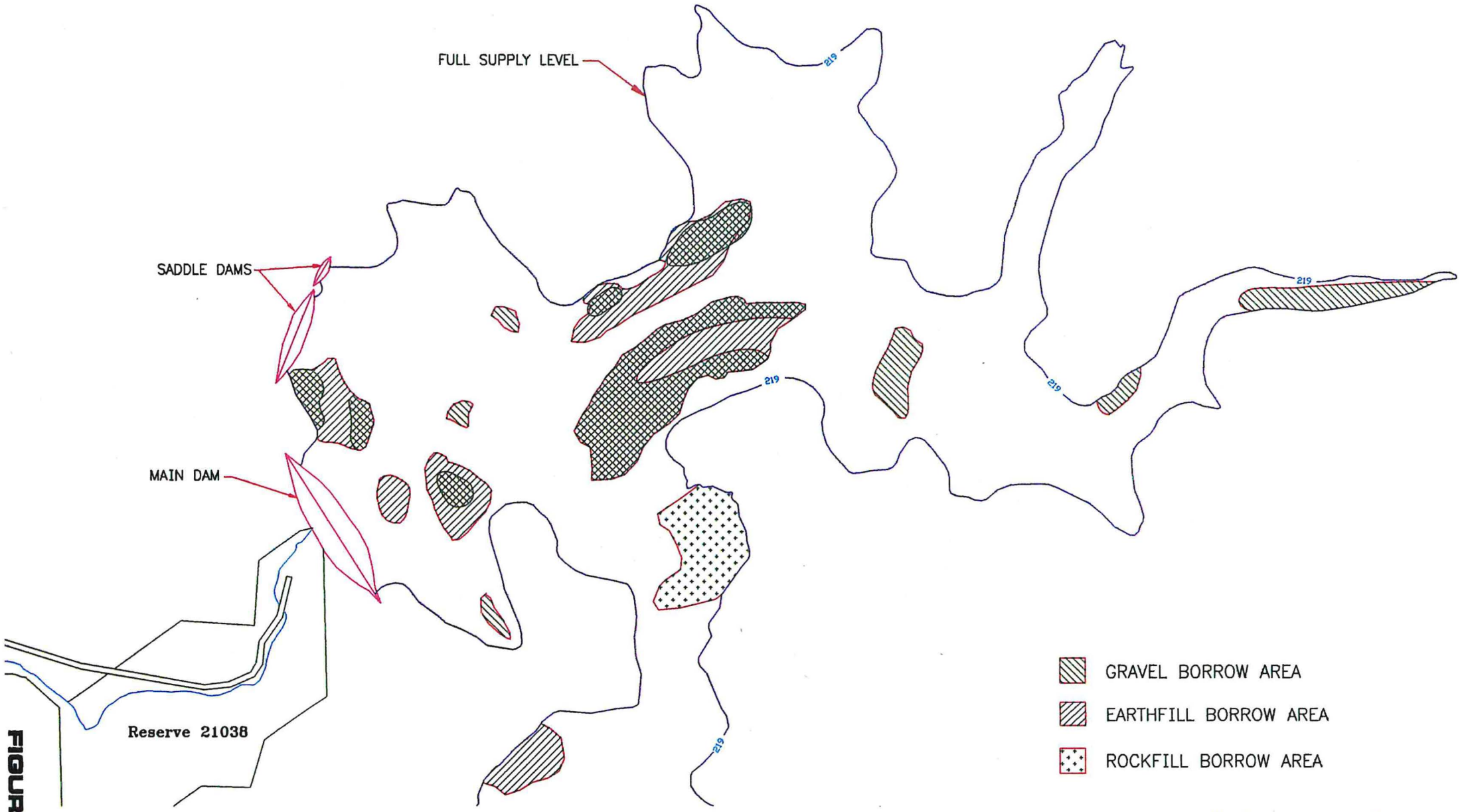
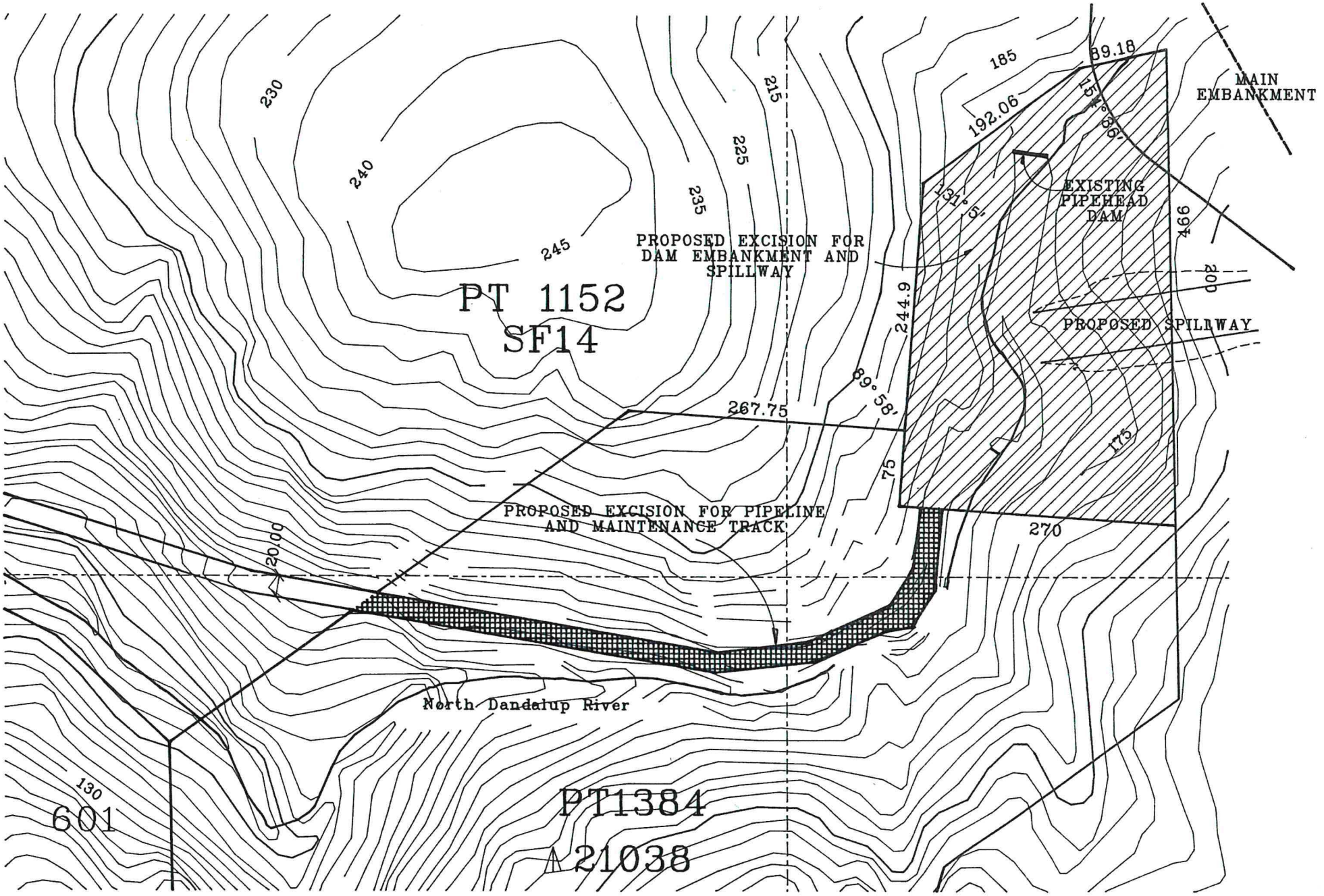


FIGURE 8

BORROW AREA PLAN


PROPOSED EXCISIONS FROM RESERVE C21038
FIGURE 9
PROPOSED EXCISION FOR DAM EMBANKMENT AND SPILLWAY
PT 1152
SF14
PROPOSED EXCISION FOR PIPELINE AND MAINTENANCE TRACK
EXISTING PIPEHEAD DAM
MAIN EMBANKMENT
PROPOSED SPILLWAY
North Dandalup River
PT1384
A21038
601
230
240
245
235
225
215
185
192.06
89.18
267.75
89°58'
244.9
75
270
175
200
994
20.00
130
RESERVE C21038
100
0
100
200
SCALE IN METRES