2.4 TOPOGRAPHY, GEOLOGY AND SOILS

2.4.1 Topography

Refer to the contour map in Figure 3.

2.4.1.1 Topography of the Property

As shown in figure 3, the topography of the property is rather complex due to the overlap and inter-relation between a range of geomorphological factors.

In general, the property includes the slopes of a large ridgeline along its northern and northwestern boundaries, which mostly fall to the south and southeast with minor drainage lines. Spurs running off this main ridge onto the site occur from the main ridge, with another crest rising to the northwest of the proposed wetland, with associated minor ridges running to the south. A spur from another ridgeline just enters the site at its west-southwest boundary and is composed of different geology. Another isolated small hill rises to the east-southeast of the wetland in the east-southeast of the property.

The far eastern section of the property consists of the sand plain (possibly a former hind dune removed by sand mining) of the adjacent coastal dune system. Topography in this area is not a true plain but appears to be a low flat dune, with an undulation down to the creek. A shallow drainage line rises just off the middle of the plain running southwest to Duchess Gully.

The sandplain is separated from the remainder of the property by the non-tidal section of Duchess Gully creek which rises at the foot of a drainage depression in the northwest of the site, and exits to the southeast by north of the isolated hill. This creek and general drainage of the property has been significantly modified by a network of artificial drains intended to improve the agricultural potential of the remainder of the property, which is essentially a coastal alluvial plain including a very broad drainage line (which lacks a well defined channel), entering the site from the south-southwest, with a tributary from the west-southwest. This drainage line encompasses two large lagoons (about 7ha in total), built as part of a previous development, and another smaller dam used for stock water in its northern extent, and exits via a modified channel on the south side of the isolated hill in the southeast to Duchess Gully.

2.4.2 Geology and Soils

The property falls into the soil landscapes in the Lake Cathie to Bonny Hills area which have been previously mapped and described by Ardill Payne & Partners (2002). The property was mapped as forming part of the Cairnscross and Moripo landscape groups.

The Cairnscross landscape comprised the lower section of the property which is described as broad drainage plains and slope-wash clays/silts with poorly drained Gleyed Podsolic soils and Sodosols. These soils are characterised by alluvial sediments, strong acidity, potential aluminium toxicity, poor drainage, seasonal waterlogging and low fertility (Ardill Payne & Partners 2002). Acid Sulphate Soils (ASS) derived from Pleistocene (not Holocene) marine deposits underlay parts of the property (Cardno 2008).

The Moripo landscape was present on the higher ground in the northern part of the property. It was described as low hills or undulating rises on metadolerites and dacites, with moderately well drained, stony, brown and yellow Dermosols and Brown Chromosols. These are stony soils, neutral to moderate alkalinity, with localised seasonal waterlogging (Ardill Payne & Partners 2002).

2.4.3 Groundwater

The flow pattern and chemical qualities of the groundwater on the property has been analysed and mapped by Cardno (2008).

Cardno (2008) reported the following salient features:

- Significant groundwater reserves occurred in the sediments especially in the east where marine sediments (derived from dune movements) dominated by sand occurred.
- Specific information on groundwater quality was limited but it is expected to be fresh (due to consistent base flow from the catchment to the ocean/Duchess Gully) with minor localised saline intrusion possibly up to the tidal limit of Duchess Gully (groundwater levels in the area subject to inundation are generally above tide level, hence limits penetration to the perimeter of the creek where a natural drawdown occurs due to Duchess Gully). Furthermore, groundwater around the adjacent sewage treatment plant is generally fresh (only brackish >4m down).
- Groundwater levels are likely to be maintained by direct rainfall onto the land affected by periodic inundation, with subsurface inflow from the western tributary (the broad drainage line entering the site from the southwest) expected to be limited by the low permeability clays. Flow from elevated areas west and north would be similarly limited.
- Groundwater flow pattern is predominantly west to east to Duchess Gully.
- No significant groundwater flow from the adjacent dune-based sewage treatment plant exfiltration into the area of periodic inundation on site, as such flows are intercepted by Duchess Gully.
- Recorded surface water quality on the area of periodic inundation is fresh, with relatively low nutrient levels (possibly increasing following storm events, etc). Due to interconnectivity with the upper aquifer, groundwater quality is likely to be similar.

2.5 LANDUSE AND DISTURBANCE HISTORY

The following information was collated from available sources as cited.

2.5.1. Clearing and Pastoralism

The property appears to have a long history of pastoralism and grazing, and most modification has resulted from this enterprise with a large proportion of the property converted to pasture and grazed by cattle in the last 30-40 years.

Historical aerial photos of the neighbouring land to the east, indicated that it had once contained more extensive areas of open forest which was largely cleared and fragmented in the late 1970's (ERM 1996), with further clearing in the early 1980's especially in the west and mid-north where large remnants had once occurred (Clancy and Ayres 1983, ERM 1996). Some of the clearing appears to be selective with pockets of open forest retained, and open woodland in other areas, with varying states and extents of regrowth also occurring. Retained eucalypt forest has also been used for selective logging for fence posts. The patterns and extent of clearing is evident in the photos in figure 4 from 1977-1989, which shows significant changes in vegetation compared to the present photo in figure 10.

An extensive drainage network eventually linked to Duchess Gully was constructed around the middle of the last century on the coastal plain (mostly as part of pastoralism and possibly modified as part of an abandoned tourist development) and has lowered the watertable, shortened standing time of surface water and hence altered edaphic conditions. This has allowed further pasture improvement and maintenance of regrowth via slashing in formerly wet areas.

In the last 10-15yrs, native regrowth has been allowed in certain areas (mostly where slashing was not practical eg due to bogging in wetter years). This primarily occurs along the riparian zone and upper reaches of Duchess Gully and along drains, resulting in linear strips of vegetation; as well as areas prone to waterlogging in all but the driest years eg parts of the western boundary and a drainage depression in the tip of the northern corridor. Swamp Oak forest on the property in general appeared to be mostly young regrowth, and has subsequently spread along the drains and wet areas on the property, demonstrating its success in colonising former pastoral land, especially where waterlogging is predominant (Darkheart 2006g, 2006a, NSWSC 2004b).

2.5.2. Abandoned Tourism/Sports Complex Proposal

The subject land was previously approved for an international sports and leisure village in the early 1980's (Cox and Corkill 1983). Works commenced on this later abandoned development including:

- Excavation of two large lagoons in the southern end of the property which were used to provide fill for about 50ha of residential development to the south (Cardno 2008).
- Construction of roads and guttering for residential land in the far southern end (now re-developed) adjacent to Bonny Hills.
- Partial construction of a golf course over the middle-south of the property (the area now proposed for the wetland and for filling.

Appraisal of the aerial photo in figure 9 shows the lagoons, the re-constructed residential area which is now fully developed, and the alignments of a number of fairways with bunkers and tees. From vegetation maps in Clancy and Ayres (1983) and the 1989 aerial in figure 4, it appears that the last major clearing events on the property occurred at this time eg removal of most of the swamp forest in the middle-south area and western side.

A double row of trees and shrubs were planted along the northern boundary of the property around this time, possibly in association with the former nursery on site (see next section). Species consist of a range of local (eg Swamp Mahogany) and non-local (eg River Oak) species, most of which have generally not developed well due to marginal edaphic conditions and exposure.

A small wetland habitat occurs north of the larger lagoon in a small depression which possibly occurs due to past construction activities on the site.

2.5.3. Abandoned Nursery

A former nursery was constructed at the head of the Swamp Oak forest in the northeastern corner of the property, but it was subsequently abandoned, and some of the nursery trees are now established in the ground.

2.5.4 Sand Mining

The coastal dune system adjacent to most of the property's east has been sand mined, as indicated by the dune scrub regrowth and modified topography. It is possible given the indicative vegetation on the sandplain of similar age east of Duchess Creek, that this portion of the property formed part of this activity ie either part of the mining area or cleared for parking, processing, etc. Sand mining is known to have historically extended to the northern fringes of Bonny Hills (RDM 1995, ERM 1996).

Figure 4: Historical aerial photos of property
(Source: Dept of Lands/LPIC, Orange. Copyright 1977-2008.)

Photo A: 1977 Aerial of southern half of property

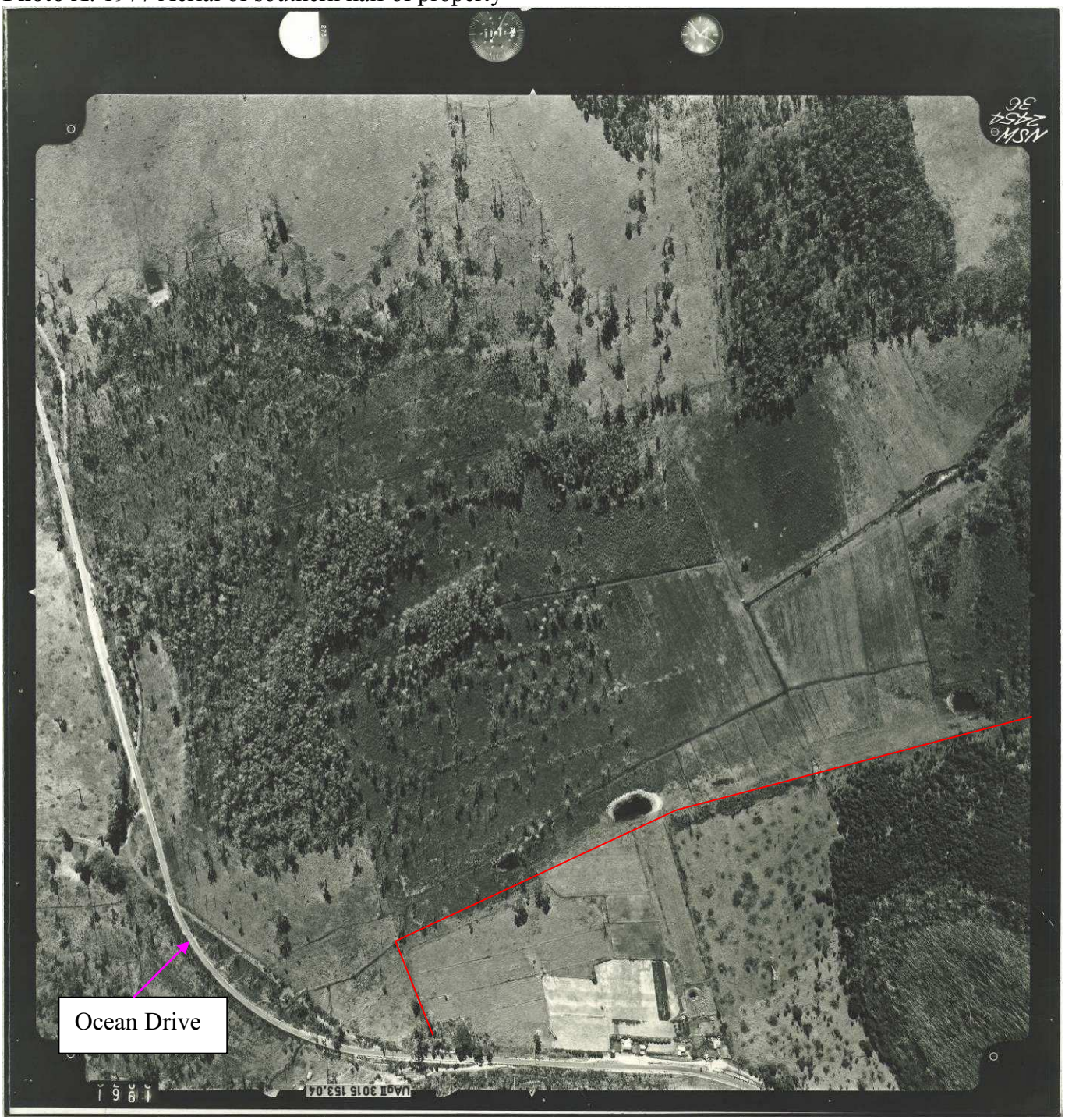
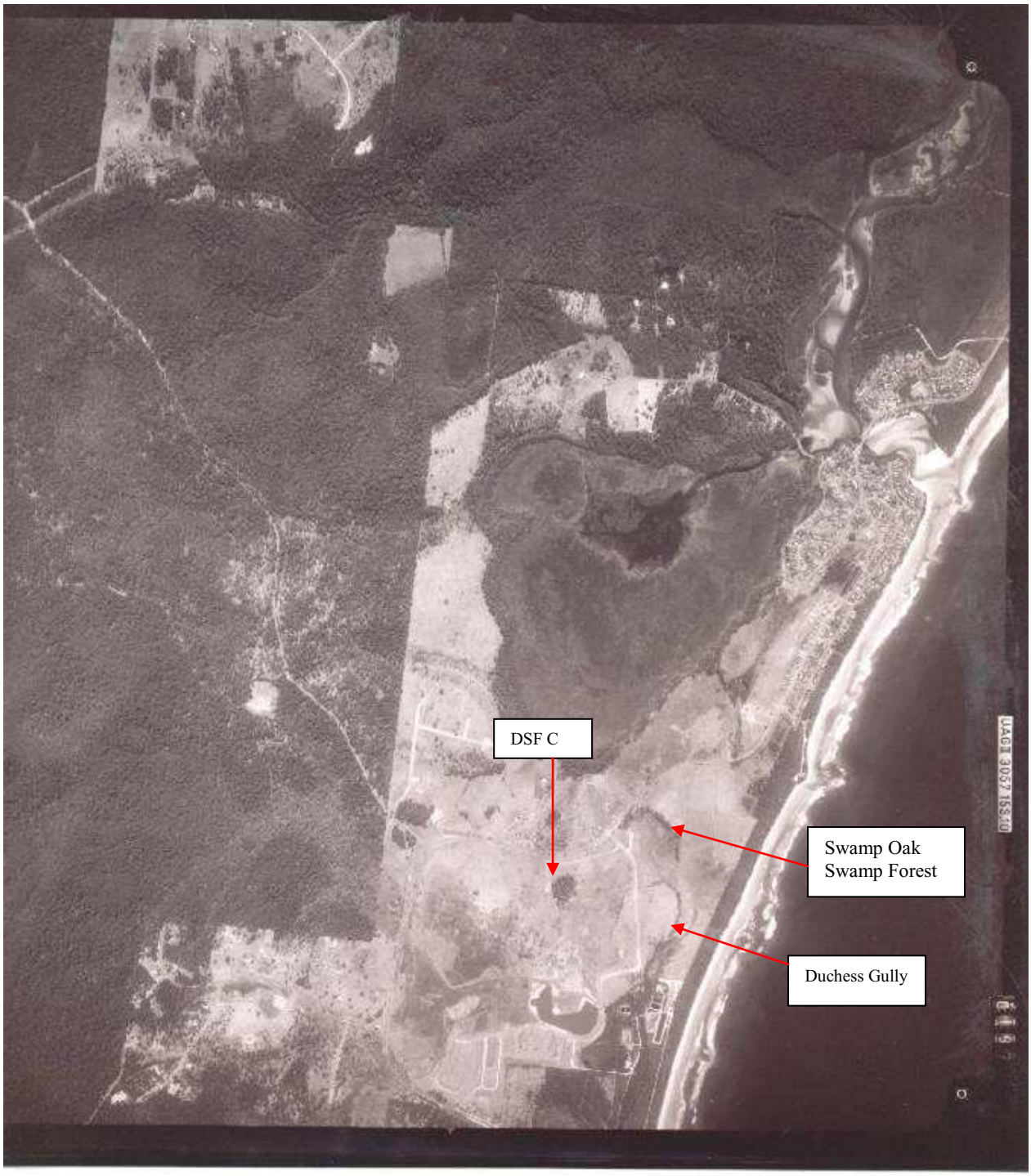


Photo B: 1989 aerial of total property.

Note the significant changes in vegetation from 1977 and compared to present in photo in figure 10.



2.5.5 Fire and Weed Invasion

A small area of grassland on the property had recently been burnt prior to the 2006 survey. The fire was restricted to a small patch of pasture land and did not impact upon any forest vegetation. No other evidence of fire was identified on the property.

Lantana was common in regrowth and forest vegetation on the property and was observed growing in dense thickets near forest edges, particularly in sections of forest along the middle sections of Duchess Gully. Lantana was also prevalent in the southeastern section of the swamp forest, where it occurred in impenetrable thickets to 2m high and had potential to dominate the understorey of this entire community if not appropriately controlled. However, weeds did not dominate the vegetation in any community (aside from pasture).

Vegetation over the majority of the property consisted largely of introduced pasture grasses with a few weed species. Pennywort was observed growing in dense clusters throughout pasture and sedge land, while Fireweed was also present on pasture land.

2.6 ADJACENT DEVELOPMENTS AND FUTURE DEVELOPMENT/PLANNING

2.6.1 Adjoining Landuses

The property is situated between the villages of Lake Cathie and Bonny Hills, and is part of a previously rural area. Consequently is it intended for urban expansion to interlink these two nodes. Subdivision of the southern end of the property has recently been completed allowing northern expansion of Bonny Hills in the last 6 years (pers. obs).

Land to the west and southwest is rural and rural-residential. Land to the northwest is currently rural/rural-residential but is intended for residential development (Deicke Richards 2004, 2003).

Land to the east is Crown land including the dune system, with SEPP 26 - *Littoral Rainforest* occurring just off the east-north east and extending to the southern end of Lake Cathie. Adjoining land to the north is the subject of another Part 3A application for residential subdivision (King and Campbell 2007).

The Bonny Hills sewage treatment plant (STP) adjoins the southeast of the site, with vegetation on the property continuous with vegetation around the STP.

2.6.2 Future Development/Planning

The property falls in the Area 14 Urban Design Structural Plan (Deicke Richards 2004, 2003), which proposes tourist, residential, education, recreation and commercial development of the property, with retention of some open spaces for drainage and habitat corridors (Figure 5). The habitat corridors essentially encompass the portion of Duchess Gully creek, to the head of the drainage depression in the property's north (northern corridor), and all of the major drainage line running roughly east-west (east-west corridor) across the property. The constructed wetland is proposed to form part of the east-west corridor.

Figure 5 Lake Cathie-Bonny Hills Structure Plan – 2004 version.
(Source: Hastings Council 2004)