CONSTRAINT MAPPING FOR AVOIDING ADVERSE EFFECTS OF DEVELOPMENT: THE APPLICATION TO POINT WILSON, AUSTRALIA, AND ITS AFTERMATH

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ABSTRACT
Avoidance of impacts on areas of environmental significance is a desired outcome of environmental planning. This paper describes the process of constraint mapping that was used in the siting and layout for a proposed petrochemical plant at Point Wilson, near Geelong, in the Australian State of Victoria. Saltmarsh vegetation on part of the proposed site was part of the prime wintering habitat for the orange-bellied parrot, a critically endangered species. Comprehensive field investigations were undertaken to determine the habitat areas and flight paths of the parrot. Other environmental factors were also defined and spatially mapped. This constraint mapping led to revising the siting and layout of the proposed petrochemical plant. As part of the rezoning process, a buffer zone was established between the industrial development zone and the conservation reserve to protect habitat areas and flight paths. The aftermath of the rezoning is considered. The petrochemical plant did not proceed on economic grounds and subsequent proposals by others for industrial development have not proceeded. The site is currently a basalt quarry. Parrot habitat protection has influenced all of these decisions. The conservation reserve became part of a Ramsar-listed site for flora and fauna protection. However, parrot numbers have declined. While there has been some degradation of the saltmarsh habitat, the decline is attributed to problems of the small population of orange-bellied parrots. A breeding programme is assisting in the recovery of parrot numbers and the conservation reserve is a key component of the reintroduction of parrots from the breeding programme into the wild.

Keywords: constraint mapping; environmental impact assessment; endangered species management.

1 INTRODUCTION
This paper considers the contribution of constraint mapping to environmental impact assessment for the avoidance of adverse impacts of proposed developments. After the introduction, the case study of the application of constraint mapping for the siting and plant layout of a proposed petrochemical plant at Point Wilson, Victoria, Australia, is presented. First the concept of constraint mapping is described followed by a brief summary of the proposed development and the surrounding land uses. While the site is well buffered from residential development, it partly covers the prime wintering habitat of the orange-bellied parrot, a critically endangered species. Next, the studies of the orange-bellied parrot are summarised.

The information on the parrot, other environmental issues, and land use compatibility considerations are discussed in relation to the constraint they pose to each major element of the plant. A siting issues matrix is set out linking constraints to the plant elements. The final step in the constraint mapping is the preparation of composite overlays. For each factor the degree of constraint is shown as grey shading for each plant element. Then, for each plant element, the constraints are combined with dark areas showing the greatest constraint and light areas showing preferred locations to avoid or minimise environmental impacts. The final outcome of the constraint mapping was a relocating of the proposed development to avoid parrot habitat and providing a buffer zone between the plant and habitat areas. This
was reflected in the rezoning decision to allow industrial zoning over part of the site and defining a rural conservation zone as a buffer to habitat areas.

The paper then considers the aftermath of the rezoning decision both in terms of industrial development and orange-bellied parrot management. While the petrochemical plant did not proceed, Point Wilson was considered for a bulk chemical storage and an expansion of the armaments complex and finally a basalt quarry. A recovery programme was established for the management of the orange-bellied parrot as an endangered species.

The paper concludes by highlighting the value of environmental impact assessment in managing the compatibility between development and habitat protection. The concluding comments also note the limitations of environmental impact assessment with respect to species recovery. There is a need for a programme of proactive interventions across all facets of parrot ecology if species survival is to be achieved.

2 THE APPLICATION OF CONSTRAINT MAPPING TO POINT WILSON

2.1 The concept of constraint mapping

One of the most valuable tools that can be used in environmental planning is constraint mapping. This concept was developed by Ian McHarg as set out in his book *Design with Nature* [1]. It consists of identifying both natural and social processes that need to be considered in designing proposed developments, in addition to the technical and economic considerations in project design.

At the plan development stage, the approach involves identifying the critical factors and ranking them from high to low in terms of their ecological or social value. For example, areas of high ecological significance such as endangered species habitat would receive a high ranking. The factors for each value are mapped with areas of higher value shown with darker tone. Where there are multiple factors, the maps are superimposed. The areas which are of high ecological and social value are shown as dark tones while areas with lower social and ecological value are revealed by the lightest tone. This enables the siting of facilities to be undertaken to avoid areas of high ecological and social value.

2.2 Proposed development at Point Wilson and surrounding land use

The process of constraint mapping was used in the planning stages of a proposed petrochemical plant at Point Wilson near Geelong. In the late 1970s, ICI Australia Ltd sought rezoning of nearly 800 ha of land at Point Wilson. The intention was to develop the site for a petrochemical chlor–alkali manufacturing complex. The ICI plant at Botany in New South Wales was being encroached by urban development and ICI was seeking a site that would be buffered from urban development. The land at Point Wilson was surrounded by Avalon Airfield, the Melbourne Metropolitan Board of Works sewage farm, Cheetham Salt Works, and a Commonwealth explosives reserve (Fig. 1). Although the site was remote from residential development, the remnant coastal saltmarsh vegetation was the prime wintering habitat for a critically endangered species – the orange-bellied parrot.

2.3 Studies of the orange-bellied parrot

Issues of concern in relation to the impact of the proposed development on the orange-bellied parrot were:

- Land development affecting habitat areas of significant bird species;
Figure 1: Point Wilson study area [2].
- High structures affecting zones of movement of significant bird species;
- Noise from plant operations disturbing bird usage of the area; and
- Plant emissions that are phytotoxic to plants used as food by significant bird species.

As part of the environmental impact assessment studies for the proposed plant [3] a detailed assessment was undertaken of the potential impacts and the significance of the nearby habitat of the orange-bellied parrot. This began with a review of previous sightings, preferred habitat, known range and ecology (e.g., [4]). A series of field programmes were undertaken to provide a more complete picture of the parrot’s ecology, habitat, and range. Continuous field observations of the parrot were undertaken around The Spit near Point Wilson. Initially, this work focussed on feeding and roosting areas (Fig. 2), parrot movements (Fig. 3) and general behaviour patterns (e.g., [2]). This work was extended to assess reaction to disturbance and effects of grazing on bird utilisation of habitat.

Figure 2: Areas used by orange-bellied parrot.  
Figure 3: Zones of movement of orange-bellied parrot [2].

The significance of The Spit as orange-bellied parrot habitat was the presence of saltmarsh. A survey of all coastal saltmarshes in Victoria was undertaken [5]. The floristic
and structural diversity of the salt marshes appeared to be important as a determinant of significance of orange-bellied parrot habitat. This was consistent with the field observations at Point Wilson which had shown that the parrot used a wide range of food sources because of their varying seeding times.

Also, two simultaneous total population counts throughout Southeast Australia were undertaken by over 100 observers across the parrot’s wintering habitat. This indicated a total population of orange-bellied parrots of less than 100 with the Point Wilson area being the prime location both in numbers and presence throughout the wintering period [6]. Investigations were also undertaken of the summer breeding area in Southwest Tasmania around the Melaleuca Lagoon area of Port Davey [7].

The hydrology of the area was investigated to determine if drainage requirements of the development might adversely affect the ecology of the habitat [8]. The change in drainage inflows due to the proposed development were found to have an insignificant effect on the system hydrology. However, it was found that an existing road embankment on the Point Wilson access road had reduced saltwater inflow to the upper saltmarsh and that a groundwater mound from nearby sewage lagoons was aiding the invasion of freshwater plant species into the saltmarsh community.

Various conservation measures were also studied. Field observations showed that sheep and rabbit grazing had a detrimental impact on habitat. The major areas were fenced to prevent sheep grazing. The studies of disturbance indicated that “sharp” rather than loud noises and visible intrusions were the most significant causes of disturbance. In the proposed development a buffer distance was provided, screen planting begun, and the development designed so that passive storage areas were on the boundary nearest the habitat areas.

2.4 Siting issues matrix

A siting issues matrix (Table 1) was developed between each major element of the petrochemical plant and the key environmental and land use compatibility factors that had been identified [9]. In addition to the concerns about the orange-bellied parrot, other factors that were considered related to adjacent land uses: the maintenance of clearance surfaces for the air traffic movement at Avalon Airfield, the effect of air emissions on sewage farm operations, the waste absorbing capacity of the receiving waters of Port Phillip Bay, and safety distances from explosives storage. The factors considered were:

- areas of orange-bellied parrot habitat – to be avoided for all plant elements;
- zones of movement of the orange-bellied parrot – to be avoided for plant elements greater than 30 m in height;
- habitat areas of other avifauna – to be avoided where possible for all plant elements;
- flight paths of other avifauna – to be avoided where possible for plant elements greater than 30 m in height;
- catchment areas of the saltmarsh – to be kept clear of plant elements from which associated spills of liquid chemicals could occur;
- areas of high permeability – to be kept free of sealed plant areas in order to maintain infiltration inflow to near-surface aquifers;
- landscaped areas set aside for regeneration or plantings – to be kept free of plant elements;
- Avalon Airfield clearance surfaces – tall structures (over 53 m) to be located beneath clearance surface for air traffic;
• Point Wilson explosives area safety distances – no plant elements to be located within the safety distances of the magazines;
• areas sensitive to air emissions – location of plant elements that emit toxic or phytotoxic emissions to be located chosen to minimise air emission concentrations in saltmarsh and sewage farm;
• areas sensitive to noise – plant elements with higher noise levels (especially high frequency noise) to be located as far as possible from parrot habitat.

Table 1: Environmental factors relevant to location of petrochemical plant elements [9].

<table>
<thead>
<tr>
<th>Environmental factors</th>
<th>Polythene</th>
<th>Polypropylene</th>
<th>Administration</th>
<th>Hydrocarbon storage</th>
<th>Liquid chemical storage</th>
<th>Caustic chlorine</th>
<th>Workshop</th>
<th>Ethylene</th>
<th>Derivative products</th>
<th>Chlorinated hydrocarbons</th>
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● Factor of some significance; ○ Factor of less significance.

2.5 Composite overlays

For each environmental factor a map was prepared indicating sensitive areas by shadings in grey tones. Areas of greatest sensitivity were shaded in the darkest tone: for example, for the permeability map, areas of $10^{-1}$ m/d permeability were shaded darker than areas of $10^{-2}$ m/d, while areas of $10^{-3}$ m/d were left clear. By overlaying the maps of environmental factors that are relevant to the siting of a particular plant element, it is possible to identify the location that has minimum environmental impact: this is the location with the lightest tone. The darker areas indicate locations of relatively greater impact.

A composite set of overlays was prepared for each plant element. In making plant layout decisions, functional, economic, technical and safety factors were also relevant. This can place limits on selecting plant elements on environmental grounds. Comparing the relative
tones with the proposed locations gives an impression of the extent to which environmental impacts have been minimised through plant layout.

Certain plant elements warranted greater consideration than others, such as the caustic chlorine plant. In order to use the site to best advantage in environmental terms, such plants are located before less critical elements were located. The caustic chlorine plant (Element 5 in Fig. 4) was located in a relatively pale grey area from an environmental impact viewpoint. Note that Element 12 is the waste treatment facility, which had already been located to provide the most advantageous outfall location.

There were different environmental constraints for other plant elements. For example, the administration complex (Element 2) was less constrained. From the areas of low impact, a location at the main entrance to the site was selected on functional grounds (Fig. 5).

By incorporating environmental and land use compatibility factors in the site layout decision making, it was possible to reduce environmental effects without compromising functional, economic, and other siting considerations. Furthermore, in the land rezoning to industrial the provision was made for a buffer zone between the industrial land and the public conservation zone – shown as “Rural Conservation Zone” in Fig. 6.

3 AFTERMATH

3.1 Industrial development

The rezoning of the ICI site at Point Wilson to industrial use was approved together with a buffer zone around the margins of the Spit Conservation Reserve zoned Rural Conservation. However, the ICI proposal for a petrochemical plant did not proceed on economic grounds.

In the 1990s, the site was considered by the Victorian Government as a bulk liquid storage terminal for hazardous chemicals. In 1991, a major fire at the Coode Island facility for
chemical storage in Melbourne led to a review of the Coode Island facility and a recommendation for siting the facility at West Point Wilson (Point Lillias). The Environment Effects Statement for the proposal concluded that construction of the facility would disturb the orange-bellied parrot and other bird species [10]. Following the Ministerial determination on the Environmental Effects Statement, the Victorian Government announced that the proposed bulk chemical storage at Point Wilson would not proceed but the Coode Island operation would be reviewed to ensure it fully meets the required environmental and safety standards.

In 1994, the Commonwealth Government nominated Point Wilson as the site for the East Coast Armaments Complex. There has been an explosives storage and jetty there since 1962. The inquiry into the proposal acknowledged the significance of the nearby parrot habitat [11]. The recommendations of the Inquiry resulted in the erection of a predator-proof fence around the eastern and southern saltmarsh habitat and the installation of more culverts beneath the Point Wilson access road to improve tidal penetration to the upper saltmarsh. The proposal has been deferred.

The former ICI site is currently (2022) operating as a basalt quarry. An expansion of quarry operations has been subject to environmental assessment [12]. The proposed expansion avoids parrot habitat, movement areas and the buffer zone. The indirect environmental issues relating to possible impacts on parrot habitat concerned effects on the catchment of The Spit including freshwater diversion and lowering of groundwater from dewatering to extract basalt deposits below the water table. These issues were considered minor compared to seawater inundation to maintain the upper saltmarsh vegetation. A monitoring and mitigation strategy in relation to these effects was recommended [13].
3.2 Orange-bellied parrot management

The initial work for ICI in 1979 prompted the conservation agencies of Victoria, Tasmania, South Australia, and the Commonwealth together with representatives from ICI, World Wide Fund for Nature (WWF), Birds Australia and Birdlife International to agree to undertake research into the status and ecology of the orange-bellied parrot [14].

The Spit Nature Conservation Reserve and substantial areas of the western shoreline of Port Phillip Bay and the Lake Connewarre wetland complex on Bellarine Peninsula were designated a Ramsar site in 1982. This was not only because of the area’s importance for orange-bellied parrots but also for wetlands and waterbirds [15].

In 1983, the Orange-Bellied Parrot Recovery Team was established to coordinate conservation activities and to guide implementation of a recovery plan. The first recovery plan was prepared in 1984. This was the first significant management plan for an endangered species in Australia. The first trial captive breeding population was established in 1986 [14]. Updated plans have been developed every five years with the most recent produced in 2016 [16].

More than one hundred years ago there were concerns for the plight of the species [17] and nearly 60 years ago the rarity of the parrot was documented [18]. However, no actions had been taken to address the decline until the recovery plans were developed and implemented.

Coordinated winter surveys were continued, relying on the contributions of more than a hundred volunteer bird observers. The number of individual parrots counted has declined from 70–90 individuals in the 1980s to fewer than 20 each year since 2001 and fewer than 10 in the 2011–2015 period. In 1992, the parrot was classified as “endangered” and reclassified as “critically endangered” in 2006 under the Environmental Protection and Biodiversity Conservation Act.

Potential wintering habitat loss was investigated as a possible cause of decline in numbers. However, little change in habitat was found since 1983 with most of the gross habitat loss occurring before then [19]. The first population viability analysis showed that high juvenile mortality was the greatest limitation on population increase. The release of 264 captive-bred birds from 1994 to 2006 at the parrot’s breeding site failed to re-establish a viable wild population [14].

In 2010, there were indications that extinction of the parrot in the wild was likely in 3–5 years. Immediate action was taken to bolster the captive population into an effective insurance population as well as a source of captive-bred parrots to release to the wild to increase the wild population [20]. Other adjustments have been made to the recovery programme; in particular, examining the fire regime at the breeding site of the parrot and which form of releasing captive birds into the wild was most effective (viz., spring release of adults to the breeding site, summer nest supplementation of eggs or nestlings, autumn fledgling release prior to winter migration, or winter release of adults/juveniles in wintering feeding areas). Controlled burns of the button-grass heath led to parrot food plants becoming more abundant. Also, the number of captive-bred fledglings released in autumn prior to northerly migration to overwintering on the mainland was increased [21].

Parrots returning to the summer breeding habitat have increased from 17 in 2017 to 70 in 2021 [22]. While the future is still uncertain, there is hope that the recovery programme is now working.
4 CONCLUDING COMMENTS

The aftermath reflects both the value and the limitations of environmental impact assessment of proposed developments. Project impact assessment was useful in the case of the proposed petrochemical plant: using constraint mapping, areas of environmental value were defined, avoidance of site development impacts could be achieved, protection of significant habitats could be incorporated in site planning, and compatibility with adjacent land uses could be managed.

In the assessment of the proposal to relocate the bulk chemical storage to Point Wilson, the potential for adverse impacts led to the selection of an alternative proposal. The inquiry into the East Coast Armaments Complex led to habitat fencing and increased culverts to facilitate greater tidal penetration to the upper saltmarsh.

However, project impact assessment was limited in what it could achieve in relation to the survival of the orange-bellied parrot. The contextual work for impact assessment defined the extent of the wintering habitat of the parrot, the local movement patterns of the parrot, and the ecohydrological connection to the catchment and seawater inundation of saltmarsh habitat. Also, baseline studies identified evidence of adverse impacts of earlier developments.

Notwithstanding, the threat to the orange-bellied parrot prime wintering site did stimulate action to address parrot recovery. This was not only the parrot recovery programme, but also the designation of wetlands related to habitat of the parrot and other bird species as a Ramsar site.

Parrot survival needed to be considered from a different perspective than project impact assessment. The parrot recovery programme considered the parrot ecosystem including the breeding areas in Southwest Tasmania, the migration paths to their wintering habitat, as well as the full range of its wintering feeding areas. There was a need for proactive interventions, such as captive breeding and reintroduction of captive-bred parrots back into the wild and addressing past effects of development such as fire regimes in parrot breeding areas and improving habitat areas through landholder agreements.

This type of proactive approach is beyond the scope of impact assessment. As stated in Martin et al. [20], there is the need for a decision process of: (i) intelligence – obtaining, processing, and delivering information to decision makers; (ii) promotion – recommending and mobilising support; (iii) prescription – turning policies into actions; (iv) invocation – implementing actions in a timely manner; (v) application – implementing the prescribed actions; (vi) appraisal – assessing whether prescriptions achieved the goal; and (vii) updating – revising prescriptions if required. They also identified a need for informed, empowered, and responsive governance and leadership. Martin and her colleagues indicate that these decision processes and governance arrangements were present for the Orange-Bellied Parrot Recovery Programme.

REFERENCES

[22] Perkins, M., The parrot clawing its way back from the brink, one nest at a time. The Age, 10 Apr. 2022.