



BTO Research Report No. 511

**The effects on waterbirds of a
new outfall discharging water
at Mansbrook Grove
on the Orwell Estuary:
2005/06 to 2007/08 Final Report**

Authors

N.H.K. Burton (BTO) & N.O.M. Ravenscroft (Wildside Ecology)

Report of work carried out by
the British Trust for Ornithology and Wildside Ecology
under contract to The T A Millard Partnership

August 2008

© British Trust for Ornithology

British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU
Charity No. 21665
Company Limited by Guarantee No 357284 (England and Wales)
Registered Office The Nunnery, Thetford, Norfolk IP24 2PU

N.H.K. Burton (BTO) & N.O.M. Ravenscroft (Wildside Ecology)

The effects on waterbirds of a
new outfall discharging water
at Mansbrook Grove
on the Orwell Estuary:
2005/06 to 2007/08 Final Report

BTO Research Report No. 511

Report of work carried out by
the British Trust for Ornithology and Wildside Ecology
under contract to The T A Millard Partnership

Entered Public Domain November 2008 and published by British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU

© British Trust for Ornithology

ISBN 978-1-906204-19-8

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form, or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publishers.

CONTENTS

	Page No.
List of Tables.....	3
List of Figures.....	5
EXECUTIVE SUMMARY	7
1. INTRODUCTION.....	9
2. METHODS.....	11
2.1 Fieldwork.....	11
2.2 Data Analysis.....	11
3. RESULTS	13
3.1 Numbers of Waterbirds in the Winters of 2005/06 to 2007/08.....	13
3.2 Changes in Densities Between 1996/97 to 1997/98 and 2005/06 to 2007/08.....	14
4. DISCUSSION.....	15
4.1 The Conservation Status of the Orwell Estuary and its Designated Features	15
4.2 The Importance of the Mudflats at Mansbrook Grove for the Waterbirds of the Orwell Estuary	15
4.3 Temporal Changes in Numbers and an Assessment of the Effect of the New Outfall....	16
Acknowledgements.....	17
References	19
Tables.....	21
Figures.....	29

List of Tables

	Page No.
Table 3.1.1	Mean and peak counts of waterbird species at Mansbrook Grove in the winters of 2005/06 to 2007/08.....21
Table 3.1.2	Mean and peak densities of waterbird species at Mansbrook Grove in the winters of 2005/06 to 2007/08.....22
Table 3.1.3	Mean and peak counts of waterbird species at Pond Hall in the winters of 2005/06 to 2007/08.....23
Table 3.1.4	Mean and peak densities of waterbird species at Pond Hall in the winters of 2005/06 to 2007/08.....24
Table 3.1.5	Mean and peak counts of waterbird species at Levington Creek in the winters of 2005/06 to 2007/08.....25
Table 3.1.6	Mean and peak densities of waterbird species at Levington Creek in the winters of 2005/06 to 2007/08.....26
Table 3.1.7	Percentages of each species recorded feeding at Mansbrook Grove, Pond Hall and Levington Creek over the winters 2005/06 to 2007/08.....27
Table 3.1.8	Comparison of the mean peak numbers of waterbirds recorded on the Mansbrook Grove mudflats between 2005/06 and 2007/08 with the mean peak numbers recorded on the Stour and Orwell Estuaries SPA by WeBS counts over the five-year period, 1995/96 to 1999/200028

List of Figures

	Page No.
Figure 2.1.1 Map of the Orwell Estuary indicating the three broad habitat types and the boundaries of each of the sectors monitored by the Wetland Bird Survey (WeBS) Low Tide Count Scheme	29
Figure 3.1.1 Variation in bird numbers recorded at Mansbrook Grove, Pond Hall and Levington Creek over the intertidal period in the winters of 2005/06 to 2007/08.....	30
Figure 3.2.1 Densities of birds recorded at low tide at Mansbrook Grove, Pond Hall and Levington Creek in the winters of 1996/97 to 1997/98 and 2005/06 to 2007/08.....	31

EXECUTIVE SUMMARY

1. As part of the development of the Ransomes Europark site on the outskirts of Ipswich a sewer was recently completed to discharge surface water run-off into the Orwell Estuary. Since 2005, water has been discharged via a short meander into the Mansbrook Grove stream at a point close to the shoreline (high tide mark) of the estuary. This report summarises the results of an investigation of the effects on waterbirds of this change.
2. Following earlier recommendations, a monitoring programme was instigated in the winter of 2005/06 to record the numbers of waterbirds within a 50 m corridor around the altered Mansbrook Grove channel, during the intertidal period, over three successive winters. Comparative counts within corridors of identical width were also carried out at two control sites within the estuary, Pond Hall, a flow of similar size to the former Mansbrook Grove channel, and Levington Creek, a flow similar to its predicted altered size.
3. A total of 18 species was recorded in numbers of 10 or more at Mansbrook Grove, including 12 of the 17 wintering species for which the Stour and Orwell Estuaries SPA is designated: Dark-bellied Brent Goose, Shelduck, Wigeon, Pintail, Ringed Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Curlew, Redshank and Turnstone. The most numerous species (occurring in numbers of 100 or more) were Dark-bellied Brent Goose, Oystercatcher, Knot, Dunlin, Black-headed Gull and Common Gull.
4. The total numbers and densities of waterbirds at Mansbrook Grove compared favourably with those found at Pond Hall and Levington, with approximately half of the species recorded at Mansbrook Grove occurring in greater numbers and at higher densities than at the other two sites. Although the importance of each flow varied between species, the overall densities found at Mansbrook Grove were most similar to those at Levington Creek and greater than those at Pond Hall, as expected from their relative predicted flow sizes.
5. Numbers of most species at Mansbrook Grove have varied between the three years of study. However, mean numbers of just four of these species were greater at Mansbrook Grove in 2007/08 than in 2005/06, whereas mean numbers of 14 were less. In comparison, mean numbers of just two of 12 species at Pond Hall and six of 19 at Levington Creek were greater in 2007/08 than in 2005/06. The declines at Pond Hall might be related to increased disturbance at this site. Disturbance is less of an issue at Mansbrook Grove and thus the declines here must be related to another factor, possibly the construction of the outfall. However, given the context of ongoing declines for the majority of (designated) species on the SPA, it is also possible that the declines at Mansbrook Grove are the result of broader-scale trends, though within the SPA it should be noted that the greater declines may have been on the Stour.
6. Comparison of the densities of waterbirds occurring at Mansbrook Grove at low tide in the winters over the winters of 2005/06 to 2007/08 with those recorded there by earlier surveys in the winters of 1996/97 and 1997/98, i.e. prior to the construction of the new outfall, suggest no overall negative or positive impact. Of the seven species found on the Stour and Orwell Estuaries SPA in internationally important numbers, two – Dunlin and Redshank – were recorded in lower densities in 2005/06 to 2007/08, whereas two others – Knot and Black-tailed Godwit – were only recorded in the latter period
7. In conclusion, the construction of the outfall to discharge water from the Ransomes Europark site into the Orwell Estuary at Mansbrook Grove does not appear to have had a positive effect on the numbers of waterbirds using this site, but a negative effect cannot be discounted. As densities of waterbirds on flows may be positively related to the rate of discharge, the predicted increase in flow size at Mansbrook Grove might have been expected to have been associated with an increase in the densities of the majority of species. Annual information

regarding the actual flow size, that would show the degree of change and variations associated with rainfall, would thus be of benefit in understanding why few increases occurred. Following the construction of the outfall, whilst many species appear to have declined during the short period of the study, the Mansbrook Grove stream has continued to support significant percentages of the bird species present on the SPA that are much greater than would be expected from its area – thus highlighting the importance of freshwater flows to waterbirds.

8. Given the annual variation that may occur in waterbird numbers, counts in future winters, for example five or 10 years hence, would be of value in determining if the construction of the outfall results in impacts in the long-term. Annual discharge data for Mansbrook Grove and comparative sites would be a prerequisite of such an evaluation.

1. INTRODUCTION

As part of the development of the Ransomes Europark site on the outskirts of Ipswich a sewer was recently completed to discharge surface water run-off into the Orwell Estuary. Since 2005, water has been discharged via a short meander into the Mansbrook Grove stream at a point close to the shoreline (high tide mark) of the estuary. This additional input was predicted to double the annual peak flow of the Mansbrook Grove stream and thus increase the flow, depth and width of the stream channel across the estuary's mudflats, though the effects would be less pronounced on lower mudflats as the primary influence here is tidal drainage (Burton & Clark 2000, Burton *et al.* 2001). This report details the results of three winters of waterbird counts at Mansbrook Grove (and comparison sites) between 2005/06 and 2007/08 aimed at determining the impact of the outfall.

The majority of the Orwell Estuary is designated a Site of Special Scientific Interest (SSSI), whilst together with the neighbouring Stour Estuary, the Orwell is protected as a Special Protection Area (SPA) and a Ramsar Site due to the importance of its wintering populations of waterbirds. According to the SPA Natura 2000 Standard Data Form (updated in May 2005: <http://www.jncc.gov.uk/pdf/SPA/UK9009121.pdf>), the Stour and Orwell Estuaries SPA holds internationally important populations of breeding Avocet *Recurvirostra avosetta* and non-breeding Dark-bellied Brent Goose *Branta bernicla bernicla*, Pintail *Anas acuta*, Grey Plover *Pluvialis squatarola*, Knot *Calidris canutus*, Dunlin *Calidris alpina alpina*, Black-tailed Godwit *Limosa limosa islandica* and Redshank *Tringa totanus*. The site also supports an overall assemblage of 63,017 waterbirds including nationally important populations of a further 10 species: Great Crested Grebe *Podiceps cristatus*, Cormorant *Phalacrocorax carbo*, Shelduck *Tadorna tadorna*, Wigeon *Anas penelope*, Gadwall *Anas strepera*, Goldeneye *Bucephala clangula*, Ringed Plover *Charadrius hiaticula*, Lapwing *Vanellus vanellus*, Curlew *Numenius arquata* and Turnstone *Arenaria interpres*. Previous work has highlighted the importance of freshwater flows to waterbird species on the SPA and other designated estuaries in south-east England (Ravenscroft & Beardall 2003).

The potential impacts of the outfall on waterbirds were assessed by Burton & Clark (2000) and Burton *et al.* (2001). While this work suggested that there was a low risk of negative impacts on bird numbers, it was recommended that a monitoring programme be set up to record and assess bird usage in the area of the outfall subsequent to construction, notably as there is an obligation to monitor the effects of developments on SPAs. This document follows on from interim reports by Maclean *et al.* (2006, 2007) to review the monitoring work undertaken over the three winters and determine whether the outfall has impacted on the numbers of birds at Mansbrook Grove (either negatively or positively).

2. METHODS

2.1 Fieldwork

Following the recommendations of Burton & Clark (2000) and Burton *et al.* (2001), a monitoring programme was instigated in the winter of 2005/06 to record the numbers (and behaviour) of waterbirds within a 50 m corridor around the altered Mansbrook Grove channel. Comparative counts within corridors of identical width were also carried out at two control sites within the estuary, Pond Hall, a flow of similar size to the former Mansbrook Grove channel, and Levington Creek, a flow similar to its predicted altered size (Fig. 2.1.1). Discharges recorded in the winters of 1996/97 to 1997/98 were between 13.1-14.5 litres/s at Mansbrook Grove, 4.8-9.7 litres/s at Pond Hall and 18.8-39.1 litres/s at Levington Creek. No information was available on the actual sizes of discharges over the winters of 2005/06 to 2007/08.

Counts were undertaken between November and February over the winters of 2005/06 to 2007/08. Numbers of birds (and their behaviour) were recorded at intervals of 2 hours at Mansbrook Grove, Pond Hall and at Levington Creek over the intertidal period (i.e. from four hours before to four hours after low tide) twice each month.

2.2 Data Analysis

This report presents a summary of the data collected over the three winters of study aimed at determining whether the outfall has impacted on the numbers of birds using Mansbrook Grove.

The mean and peak numbers and densities of waterbirds recorded at Mansbrook Grove were first evaluated to determine if there were any changes over the three years of study. A broad assessment was made of the numbers of species showing increases or decreases between 2005/06 and 2007/08 at Mansbrook Grove and the two control sites. Generalised Linear Models (GLMs) were also used to highlight species showing significant changes in numbers between years in the tabulated results. Models assumed a Poisson distribution for the number of birds counted, a log link function, and a scale factor estimated from the square root of the Pearson's Chi-squared statistic divided by its degrees of freedom to account for overdispersion.

Secondly, the mean and peak numbers and densities of bird species recorded at Mansbrook Grove were compared to those recorded at the other two flows.

Lastly, the waterbird densities recorded at low tide at each flow over the winters of 2005/06 to 2007/08 were compared, statistically and graphically, to those recorded at the same sites by earlier surveys in the winters of 1996/97 and 1997/98, i.e. prior to the construction of the new outfall (Ravenscroft *et al.* 1997, Ravenscroft 1998). As the 1996/97 to 1997/98 data were collected assuming a 20 m corridor around the stream corridors, numbers are not comparable between the two periods and hence a comparison of densities is used here. Caution is still needed in interpreting these figures, though, as higher densities of birds might be expected to occur closer to the streams (if they are attracted to these features), and thus in the 20 m corridors used in the earlier period. Nevertheless, a comparison of trends at the three sites between 1996/97 to 1997/98 and 2005/06 to 2007/08 should provide some indication of whether any changes in densities observed at Mansbrook Grove were due to actual changes there rather than just the change in the width of the survey section.

Low tide counts were compared between 1996/97 to 1997/98 and 2005/06 to 2007/08 using Generalised Linear Models (GLMs). As above, models assumed a Poisson distribution for the number of birds counted, a log link function and accounted for overdispersion, but additionally used the natural logarithm of area (ha) as an offset.

To place the importance of the mudflats around Mansbrook Grove in greater context, the peak numbers of waterbirds recorded there in 2005/06 and 2006/07 are compared to the average peak

winter numbers for 1995/96 to 1999/2000 for the entire Stour and Orwell Estuaries SPA, using data from Wetland Bird Survey (WeBS) Core Counts taken from the SPA Natura 2000 Standard Data Form. WeBS Core Counts are undertaken monthly on wetland sites across the UK in order to monitor waterbird populations and the status of sites; counts at coastal sites are typically undertaken at high tide. Only species for which the SPA is designated were included in this analysis.

Trend data for the SPA as a whole, reported in Maclean & Austin (2008), are also referenced to place any changes observed at Mansbrook Grove between 1996/97 to 1997/98 and 2005/06 to 2007/08 in context.

3. RESULTS

3.1 Numbers of Waterbirds in the Winters of 2005/06 to 2007/08

Mean and peak counts and densities of waterbird species recorded over the winters of 2005/06 to 2007/08 at Mansbrook Grove, Pond Hall and Levington Creek are shown in Tables 3.1.1-3.1.6.

For most species, feeding was the main activity recorded (Table 3.1.7). The percentage of birds recorded feeding was greatest for waders and least for gulls. For most wildfowl species, under half of birds counted were recorded as feeding. There were no clear differences in the percentages of birds recorded feeding between sites.

Figure 3.1.1 shows how species' numbers varied across the tidal cycle at each of the three sites for those species that occur on the Stour and Orwell Estuaries SPA in internationally important populations. For five species – Dark-bellied Brent Goose, Pintail, Grey Plover, Black-tailed Godwit and Redshank – Mansbrook Grove tended to hold higher numbers around the low tide period. In contrast, numbers of Knot and Dunlin were greatest at the start of the intertidal period.

Typically, the other two sites also tended to hold higher numbers of most species around the low tide period. However, Levington Creek held higher numbers of Knot and Dunlin at the end of the intertidal period, presumably as birds roosted over high tide nearby. Numbers of Knot and Black-tailed Godwit at Pond Hall were also greatest at the start of the intertidal period.

A total of 18 species was recorded in numbers of 10 or more at Mansbrook Grove (Table 3.1.1), including 12 of the 17 wintering species for which the Stour and Orwell Estuaries SPA is designated: Dark-bellied Brent Goose, Shelduck, Wigeon, Pintail, Ringed Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Curlew, Redshank and Turnstone. The most numerous species (occurring in numbers of 100 or more) were Dark-bellied Brent Goose, Oystercatcher *Haematopus ostralegus*, Knot, Dunlin, Black-headed Gull *Chroicocephalus ridibundus* and Common Gull *Larus canus*.

Numbers of most species at Mansbrook Grove have varied between the three years of study. Of those recorded in numbers of 10 or more, peak numbers of five were more in the final winter (2007/08) than the first (2005/06), whereas peak numbers of 13 species were less, an insignificant difference (Sign Test $P = 0.10$). In comparison, mean numbers of just four of these species were greater in 2007/08 than in 2005/06, whereas mean numbers of 14 were less, a significant difference ($P = 0.03$).

Of those species recorded in numbers of 10 or more at Pond Hall, peak numbers of four species were greater in 2007/08 than in 2005/06, whereas peak numbers of eight were less ($P = 0.39$). In comparison, mean numbers of just two of these species were greater in 2007/08 than in 2005/06, whereas those of 10 were less, a significant difference ($P = 0.04$).

Of those species recorded in numbers of 10 or more at Levington Creek, peak numbers of seven were greater in 2007/08 than in 2005/06, whereas peak numbers of 12 were less ($P = 0.36$). In comparison, mean numbers of six of these species were greater in 2007/08 than in 2005/06, whereas those of 13 were less, this difference also not being significant ($P = 0.17$).

Among the 18 species recorded in numbers of 10 or more at Mansbrook Grove, greater peak numbers of 12 were recorded at Mansbrook Grove than on both the two control creeks across the three winters: Dark-bellied Brent Goose, Shelduck, Oystercatcher, Lapwing, Knot, Curlew, Redshank, Turnstone, Black-headed Gull, Common Gull, Lesser Black-backed Gull *Larus fuscus* and Herring Gull *Larus argentatus*. Six species – Wigeon, Pintail, Ringed Plover, Golden Plover, Dunlin and Black-tailed Godwit – were recorded in lower peak numbers at Mansbrook Grove. Teal *Anas crecca*, Avocet and Grey Plover were also recorded at Levington Creek in numbers of 10 or more.

Greater mean numbers of 10 species were recorded at Mansbrook Grove than on the two control creeks across the three winters: Pintail, Oystercatcher, Lapwing, Curlew, Redshank, Turnstone, Black-headed Gull, Common Gull, Lesser Black-backed Gull and Herring Gull. Eight species – Dark-bellied Brent Goose, Shelduck, Wigeon, Ringed Plover, Golden Plover, Grey Plover, Knot and Dunlin – were recorded in lower mean numbers at Mansbrook Grove.

Again, among species recorded in numbers of 10 or more there, Mansbrook Grove held both higher peak and mean densities of eight species – Oystercatcher, Lapwing, Redshank, Turnstone, Black-headed Gull, Common Gull, Lesser Black-backed Gull and Herring Gull – than the other two sites. Ten species – Dark-bellied Brent Goose, Shelduck, Wigeon, Pintail, Ringed Plover, Golden Plover, Knot, Dunlin, Black-tailed Godwit and Curlew – were recorded in lower peak and mean densities at Mansbrook Grove.

To place the importance of the mudflats around Mansbrook Grove in context, the means of the peak numbers of designated species recorded there over the winters of 2005/06 to 2007/08 were compared to the mean peak numbers recorded on the entire Stour and Orwell Estuaries SPA over the five-year period, 1995/96 to 1999/2000 (using data from WeBS Core Counts taken from the SPA Natura 2000 Standard Data Form: Table 3.1.8). This evaluation indicated that numbers of both Dark-bellied Brent Goose and Turnstone at Mansbrook Grove exceeded 5% of the five-year mean peak numbers for the SPA. Among other species, mean peak numbers of Wigeon, Pintail, Cormorant, Ringed Plover, Knot, Black-tailed Godwit and Redshank at Mansbrook Grove also exceeded 1% of the species' respective five-year mean peak numbers for the SPA, this despite Mansbrook Grove comprising less than 0.25% of the total area of the SPA. Only three of the SPA's designated species – Gadwall, Goldeneye and Great Crested Grebe – were not recorded at Mansbrook Grove over the course of the three winters.

3.2 Changes in Densities Between 1996/97 to 1997/98 and 2005/06 to 2007/08

Figure 3.2.1 compares the mean densities of waterbirds recorded at low tide at each of the three sites over the winters of 2005/06 to 2007/08 with those recorded there by earlier surveys in the winters of 1996/97 and 1997/98, i.e. prior to the construction of the new outfall. Graphs are shown for the seven species that occur on the Stour and Orwell Estuaries SPA in internationally important populations.

In comparison to the peak densities that may be recorded, these mean densities are quite low for most species, with the exception of Dunlin and Redshank. The figures also indicate that there was considerable inter-annual variation in species' densities over the two periods considered.

Neither Knot or Black-tailed Godwit were recorded at Mansbrook Grove at low tide in the winters of 1996/97 and 1997/98, though both species were present over the winters of 2005/06 to 2007/08. In contrast, analyses indicated that densities of both Dunlin ($F_{1,30} = 44.48$, $P < 0.0001$) and Redshank ($F_{1,30} = 16.19$, $P = 0.0004$) were significantly less in 2005/06 to 2007/08. No significant differences were found for Dark-bellied Brent Goose ($F_{1,30} = 0.24$, $P = 0.63$), Pintail ($F_{1,30} = 2.21$, $P = 0.15$) or Grey Plover ($F_{1,30} = 3.85$, $P = 0.06$).

Low tide densities of several species were lower at Pond Hall than the other two sites (Fig. 3.2.1). No Knot were recorded there in either period and Dark-bellied Brent Geese were only present in low numbers in winter 2005/06. Densities of Grey Plover ($F_{1,25} = 15.35$, $P = 0.0006$), Dunlin ($F_{1,25} = 30.31$, $P < 0.0001$) and Redshank ($F_{1,25} = 17.04$, $P = 0.0004$) at low tide were all significantly less in the latter period. No significant differences were found for Pintail ($F_{1,25} = 2.88$, $P = 0.10$) and Black-tailed Godwit ($F_{1,25} = 0.98$, $P = 0.33$).

Dark-bellied Brent Goose, Knot and Black-tailed Godwit were not recorded at Levington Creek at low tide in the winters of 1996/97 and 1997/98, though all three species were present over the winters of 2005/06 to 2007/08. Densities of both Grey Plover ($F_{1,30} = 14.91$, $P = 0.0006$) and Redshank ($F_{1,30} = 277.8$, $P < 0.0001$) were significantly less in the latter period, whereas no significant differences were found for Pintail ($F_{1,30} = 3.67$, $P = 0.06$) or Dunlin ($F_{1,30} = 0.03$, $P = 0.86$).

4. DISCUSSION

4.1 The Conservation Status of the Orwell Estuary and its Designated Features

Mansbrook Grove, together with Levington Creek and Pond Hall, all lie within the Stour and Orwell Estuaries SPA (Stroud *et al.* 2001). There is a high threat posed to this SPA by erosion and habitat loss through dredging, and there has also been major loss of intertidal land due to port/commercial development at Fagbury Flats (Armitage *et al.* 2003). Other threats posed to the waterbirds that use this complex include oil, industrial and sewage pollution, sea-level rise that may lead to flooding, industrial and recreational developments and disturbance, changes in waste-water treatment, a decrease in freshwater flow to the estuary due to increased water-abstraction, and bait-digging (Maclean & Austin 2008). These threats are likely to have already affected the birds that are designated features of the site. Of 17 species evaluated, three – Great Crested Grebe, Ringed Plover and Dunlin – had undergone declines of greater than 50% over either the most recent 5, 10 or 25 years and a further nine – Dark-bellied Brent Goose, Shelduck, Wigeon, Pintail, Goldeneye, Cormorant, Lapwing, Black-tailed Godwit and Redshank – had declined by more than 25% over the last 5, 10 or 25 years (Maclean & Austin 2008).

4.2 The Importance of the Mudflats at Mansbrook Grove for the Waterbirds of the Orwell Estuary

Despite comprising less than 0.10% of the total area of the Stour and Orwell Estuaries SPA, the mudflats around Mansbrook Grove held significant percentages of the bird species present within it. The peak numbers recorded at Mansbrook Grove of nine of the SPA's 17 designated species exceeded 1% of the five-year mean peak numbers on the entire SPA. Those of two species – Dark-bellied Brent Goose and Turnstone – exceeded 5% of the mean peak numbers on the SPA.

The total numbers and densities of waterbirds at Mansbrook Grove compare favourably with those found at the other freshwater flows at Pond Hall and Levington, with approximately half of the species recorded at Mansbrook Grove occurring in greater numbers and at higher densities than at the other two sites. Although the importance of each flow varied between species, the overall densities found at Mansbrook Grove were most similar to those at Levington Creek and greater than those at Pond Hall, as expected from their relative predicted flow sizes. The stream at Mansbrook Grove tends to be particularly favourable for waterbirds, not only because of the size of its flow, but also its length. This means that disturbance to waterbirds at the tide's edge tends to be lower than at sites such as Pond Hall, where the shore is narrower and access greater, and human disturbance, for example from bait-diggers, is thus greater.

The data serve to illustrate the significance of freshwater flows for estuarine waterbirds. A previous comparison of the densities of waterbirds on all freshwater stream corridors in the estuary with those of the estuary as a whole, revealed that densities in stream corridors are usually considerably higher (Ravenscroft & Beardall 2003). The importance of freshwater flows and other drainage channels in supporting feeding and resting estuarine waterbirds is well documented (e.g. Ravenscroft & Beardall 2003, Lourenço *et al.* 2005) with large proportions of the estuary populations of several species sometimes occurring around flows (Ravenscroft & Beardall 2003). The attraction of freshwater on mudflats to waterbirds is probably attributable to the presence of water for preening and drinking close to their feeding grounds and microclimate and shelter may also be enhanced (Ravenscroft & Beardall 2003). The high nutrient levels likely to be present in the Mansbrook Grove outflow, whilst potentially detrimental to some features of the estuary, are unlikely to adversely affect waterbirds. Indeed, enhanced nutrient levels, except on the most grossly polluted sites, have the potential to lead to increases in waterbird numbers due to increases in the abundance, biomass and diversity of invertebrates (Burton *et al.* 2002). However, although it has been shown that the density of their macroinvertebrate prey may be higher in saltwater drainage channels (Lourenço *et al.* 2005), this may not necessarily be true at freshwater flows (Ravenscroft & Emes 2004).

4.3 Temporal Changes in Numbers and an Assessment of the Effect of the New Outfall

Comparison of the densities of waterbirds occurring at Mansbrook Grove at low tide in the winters over the winters of 2005/06 to 2007/08 with those recorded there by earlier surveys in the winters of 1996/97 and 1997/98, i.e. prior to the construction of the new outfall, suggest no overall negative or positive impact. Of the seven species found on the Stour and Orwell Estuaries SPA in internationally important numbers, two – Dunlin and Redshank – were recorded in lower densities in 2005/06 to 2007/08, whereas two others – Knot and Black-tailed Godwit – were only recorded in the latter period. Dunlin and Redshank densities had also declined at Pond Hall and those of Redshank at Levington Creek, suggesting that the declines at Mansbrook Grove were unrelated to the construction of the outfall. WeBS counts also indicate that both these species have declined over this period on the SPA as a whole, whereas those of Knot have shown a large increase (Maclean & Austin 2008).

Between 2005/06 and 2007/08, mean numbers of a majority of species showed declines at Mansbrook Grove. However, numbers of most species also declined at Pond Hall and to a lesser extent at Levington Creek. The declines at Pond Hall might be related to increased disturbance at this site, e.g. from bait-diggers. Disturbance is less of an issue at Mansbrook Grove and thus the declines here must be related to another factor, possibly the construction of the outfall. However, given the context of ongoing declines for the majority of (designated) species on the SPA (Maclean & Austin 2008), it is also possible that the declines at Mansbrook Grove are the result of broader-scale trends, though within the SPA it should be noted that the greater declines may have been on the Stour.

In conclusion, the construction of the outfall to discharge water from the Ransomes Europark site into the Orwell Estuary at Mansbrook Grove does not appear to have had a positive effect on the numbers of waterbirds using this site, but a negative effect cannot be discounted. As densities of waterbirds (e.g. Shelduck, Grey Plover, Dunlin, Curlew and Redshank: Ravenscroft 1988) on flows may be positively related to the rate of discharge, the predicted increase in flow size at Mansbrook Grove might have been expected to have been associated with an increase in the densities of the majority of species. Annual information regarding the actual flow size, that would show the degree of change and variations associated with rainfall, would thus be of benefit in understanding why few increases occurred. Following the construction of the outfall, whilst many species appear to have declined during the short period of the study, the Mansbrook Grove stream has continued to support significant percentages of the bird species present on the SPA that are much greater than would be expected from its area – thus highlighting the importance of freshwater flows to waterbirds.

Given the annual variation that may occur in waterbird numbers, counts in future winters, for example five or 10 years hence, would be of value in determining if the construction of the outfall results in impacts in the long-term. Annual discharge data for Mansbrook Grove and comparative sites would be a prerequisite of such an evaluation.

Acknowledgements

We thank Graham Gilleberg and the TA Millard Partnership for their help with this work. Maria Knight and Heidi Mellan helped with data inputting and the final formatting of the report. Waterbird counts between 2005/06 and 2007/08 were conducted by Neil Ravenscroft, Eddie Marsh, David Andrew Raine and Mick Wright.

References

Armitage, M.J.S., Austin, G.E., Ravenscroft, N.O.M. & Rehfisch, M.M. (2003) *Towards determining the causes of declines in waterbird numbers on the Stour and Orwell Estuaries SPA*. BTO Research Report No. 338 to Posford Haskoning Ltd. BTO, Thetford.

Burton, N.H.K. & Clark, N.A. (2000) *The ecological effect of the proposed Mansbrook Grove outfall with particular reference to birds on the adjacent mudflats of the Orwell Estuary*. BTO Research Report No. 243 to The TA Millard Partnership. BTO, Thetford.

Burton, N.H.K., Clark, N.A. & Ravenscroft, N.O.M. (2001) *The ecological effect of the proposed outfall from Ransomes Europark into Mansbrook Grove with particular reference to birds of the Orwell Estuary Special Protection Area*. Report to The TA Millard Partnership. BTO, Suffolk Wildlife Trust, Dr N.O.M. Ravenscroft (Ecological Research Associates) & HR Wallingford.

Burton, N.H.K., Paipai, E., Armitage, M.J.S., Maskell, J.M., Jones, E.T., Hutchings, C.J. & Rehfisch, M.M. (2002) *Effects of reductions in organic and nutrient loading on bird populations in estuaries and coastal waters of England and Wales. Phase 1 Report*. BTO Research Report No. 267 to English Nature, the Countryside Council for Wales and the Environment Agency. BTO, Thetford.

Lourenço, P.M., Granadeiro, J.P. & Palmeirim, J.M. (2005) Importance of drainage channels for waders foraging on tidal mudflats: relevance for the management of estuarine wetlands. *Journal of Applied Ecology*: **42**, 477-486.

Macleán, I.M.D. & Austin, G.E. (2008) *WeBS Alerts 2004/2005 (Release 2): changes in numbers of wintering waterbirds in the United Kingdom, its constituent countries, Special Protection Areas (SPAs) and Sites of Special Scientific Interest (SSSIs)*. BTO Research Report 492 to the WeBS Partnership. BTO, Thetford.
<http://www.bto.org/webs/alerts/alerts/>

Macleán, I.M.D., Burton, N.H.K. & Ravenscroft, N.O.M. (2006) *The effects on waterbirds of a new outfall discharging water into Mansbrook Grove on the Orwell Estuary: Interim Report for 2005/06*. BTO Report to The T A Millard Partnership. BTO, Thetford.

Macleán, I.M.D., Burton, N.H.K. & Ravenscroft, N.O.M. (2007) *The effects on waterbirds of a new outfall discharging water into Mansbrook Grove on the Orwell Estuary: Interim Report for 2006/07*. BTO Report to The T A Millard Partnership. BTO, Thetford.

Musgrove, A.J., Langston, R.H.W., Baker, H. & Ward, R.M. (eds.) (2003) *Estuarine waterbirds at low tide: the WeBS Low Tide Counts 1992-93 to 1998-99*. WSG/BTO/WWT/RSPB/JNCC, Thetford.

Ravenscroft, N.O.M. (1998) *Associations of wintering waterfowl with freshwater on the mudflats of East Anglian estuaries*. Report to the Environment Agency, English Nature and Suffolk Wildlife Trust.

Ravenscroft, N.O.M. & Beardall, C.H. (2003) The importance of freshwater flows over estuarine mudflats for wintering waders and wildfowl. *Biological Conservation*: **113**, 89-97.

Ravenscroft, N.O.M., Beardall, C.H., Cottle, R., Willet, P. & Wright, M.T. (1997) *The distribution of wintering waterfowl around freshwater flows over the mudflats of the Orwell estuary, England*. Report to the Environment Agency and English Nature.

Ravenscroft, N.O.M. & Emes, C.H. (2004) *Freshwater flows and birds in estuaries: relationships with sediment and invertebrates*. Era Report No. 31 to the Environment Agency.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, I., Baker, H. & Whitehead, S. (2001) *The UK SPA network: its scope and content*. JNCC, Peterborough, UK.

Table 3.1.1 Mean and peak counts of waterbird species at Mansbrook Grove in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	0.53	13	8.53	202	7.20	252
Shelduck*	3.43	23	1.88	10	4.82	47
Wigeon*	17.03	44	12.98	40	8.80	35
Teal	0	0	0	0	0	0
Mallard	0.05	2	0	0	0	0
Pintail*	9.00	40	6.20	41	0.93	18
Shoveler	0.05	2	0	0	0	0
Great Crested Grebe	0	0	0	0	0	0
Cormorant	0.03	1	0.08	3	0.18	4
Little Egret	0	0	0	0	0	0
Oystercatcher*	55.53	390	17.50	79	21.56	133
Avocet	0	0	0	0	0	0
Ringed Plover	0.63	14	0	0	0	0
Golden Plover	0.68	15	0	0	0.04	2
Grey Plover	0.53	7	0.45	6	0.11	3
Lapwing*	3.83	95	1.58	32	1.56	24
Knot	4.58	110	3.78	35	1.36	26
Dunlin	7.55	138	9.75	179	3.58	46
Black-tailed Godwit*	4.83	55	0.55	15	4.56	62
Bar-tailed Godwit	0	0	0	0	0	0
Curlew	3.50	18	5.50	24	3.11	14
Redshank*	14.28	56	9.28	34	6.73	27
Turnstone*	9.10	72	3.53	31	5.00	44
Black-headed Gull*	281.50	937	223.53	1013	75.84	381
Common Gull*	42.68	255	8.93	40	8.29	47
Lesser Black-backed Gull*	1.43	12	4.40	34	1.93	36
Herring Gull*	2.33	11	6.18	21	7.84	44
Great Black-backed Gull	0.23	2	0.25	5	0.40	8

Peak values are highlighted.

* – species whose numbers varied significantly between years according to GLMs (see methods).

Table 3.1.2 Mean and peak densities of waterbird species at Mansbrook Grove (area = 3.125 ha) in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	0.17	4.16	2.73	64.64	2.30	80.64
Shelduck	1.10	7.36	0.60	3.20	1.54	15.04
Wigeon	5.45	14.08	4.15	12.80	2.82	11.20
Teal	0	0	0	0	0	0
Mallard	0.02	0.64	0	0	0	0
Pintail	2.88	12.80	1.98	13.12	0.30	5.76
Shoveler	0.02	0.64	0	0	0	0
Great Crested Grebe	0	0	0	0	0	0
Cormorant	0.01	0.32	0.02	0.96	0.06	1.28
Little Egret	0	0	0	0	0	0
Oystercatcher	17.77	124.80	5.60	25.28	6.90	42.56
Avocet	0	0	0	0	0	0
Ringed Plover	0.20	4.48	0	0	0	0
Golden Plover	0.22	4.80	0	0	0.01	0.64
Grey Plover	0.17	2.24	0.14	1.92	0.04	0.96
Lapwing	1.22	30.40	0.50	10.24	0.50	7.68
Knot	1.46	35.20	1.21	11.20	0.43	8.32
Dunlin	2.42	44.16	3.12	57.28	1.14	14.72
Black-tailed Godwit	1.54	17.60	0.18	4.80	1.46	19.84
Bar-tailed Godwit	0	0	0	0	0	0
Curlew	1.12	5.76	1.76	7.68	1.00	4.48
Redshank	4.57	17.92	2.97	10.88	2.15	8.64
Turnstone	2.91	23.04	1.13	9.92	1.60	14.08
Black-headed Gull	90.08	299.84	71.53	324.16	24.27	121.92
Common Gull	13.66	81.60	2.86	12.80	2.65	15.04
Lesser Black-backed Gull	0.46	3.84	1.41	10.88	0.62	11.52
Herring Gull	0.74	3.52	1.98	6.72	2.51	14.08
Great Black-backed Gull	0.07	0.64	0.08	1.60	0.13	2.56

Peak values are highlighted.

Table 3.1.3 Mean and peak counts of waterbird species at Pond Hall in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	0.10	4	0	0	0	0
Shelduck*	4.44	41	0.34	4	2.03	21
Wigeon*	26.69	160	17.89	143	12.94	75
Teal	0.03	1	0	0	0	0
Mallard	0.10	4	0.06	2	0.15	5
Pintail	4.03	38	5.83	32	3.56	37
Shoveler	0	0	0	0	0	0
Great Crested Grebe	0	0	0	0	0.06	1
Cormorant	0	0	0	0	0	0
Little Egret	0	0	0.03	1	0	0
Oystercatcher*	9.26	73	17.26	78	8.68	94
Avocet	0	0	0	0	0	0
Ringed Plover	0.31	7	0	0	0	0
Golden Plover	0.05	2	0	0	0	0
Grey Plover	0.23	6	0.03	1	0.03	1
Lapwing	0.05	2	0	0	0	0
Knot*	1.51	33	0	0	0.91	31
Dunlin*	9.49	114	0.54	7	1.32	45
Black-tailed Godwit	3.41	39	5.54	90	5.97	105
Bar-tailed Godwit	0	0	0	0	0	0
Curlew	0.97	5	0.66	7	0.47	4
Redshank*	5.67	15	2.20	9	0.59	6
Turnstone*	2.64	34	0.91	15	0.38	6
Black-headed Gull*	124.54	524	81.11	191	60.79	173
Common Gull*	5.87	25	1.74	9	3.97	52
Lesser Black-backed Gull	0.15	2	0.17	2	0.12	1
Herring Gull	0.74	4	0.86	7	1.41	14
Great Black-backed Gull*	0.08	1	0	0	0.09	1

Peak values are highlighted.

* – species whose numbers varied significantly between years according to GLMs (see methods).

Table 3.1.4 Mean and peak densities of waterbird species at Pond Hall (area = 1.875 ha) in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	0.05	2.13	0	0	0	0
Shelduck	2.37	21.87	0.18	2.13	1.08	11.20
Wigeon	14.24	85.33	9.54	76.27	6.90	40
Teal	0.01	0.53	0	0	0	0
Mallard	0.05	2.13	0.03	1.07	0.08	2.67
Pintail	2.15	20.27	3.11	17.07	1.90	19.73
Shoveler	0	0	0	0	0	0
Great Crested Grebe	0	0	0	0	0.03	0.53
Cormorant	0	0	0	0	0	0
Little Egret	0	0	0.02	0.53	0	0
Oystercatcher	4.94	38.93	9.20	41.60	4.63	50.13
Avocet	0	0	0	0	0	0
Ringed Plover	0.16	3.73	0	0	0	0
Golden Plover	0.03	1.07	0	0	0	0
Grey Plover	0.12	3.20	0.02	0.53	0.02	0.53
Lapwing	0.03	1.07	0	0	0	0
Knot	0.81	17.60	0	0	0.49	16.53
Dunlin	5.06	60.80	0.29	3.73	0.71	24.00
Black-tailed Godwit	1.82	20.80	2.96	48.00	3.18	56.00
Bar-tailed Godwit	0	0	0	0	0	0
Curlew	0.52	2.67	0.35	3.73	0.25	2.13
Redshank	3.02	8.00	1.17	4.80	0.31	3.20
Turnstone	1.41	18.13	0.49	8.00	0.20	3.20
Black-headed Gull	66.42	279.47	43.26	101.87	32.42	92.27
Common Gull	3.13	13.33	0.93	4.80	2.12	27.73
Lesser Black-backed Gull	0.08	1.07	0.09	1.07	0.06	0.53
Herring Gull	0.40	2.13	0.46	3.73	0.75	7.47
Great Black-backed Gull	0.04	0.53	0	0	0.05	0.53

Peak values are highlighted.

Table 3.1.5 Mean and peak counts of waterbird species at Levington Creek in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	5.67	120	11.39	190	4.80	88
Shelduck*	5.07	23	0.78	13	0.90	11
Wigeon	22.44	85	22.07	104	20.06	106
Teal*	2.78	14	0.92	19	3.32	40
Mallard*	0.31	2	0	0	0.11	2
Pintail*	4.71	94	0.90	14	0	0
Shoveler	0	0	0	0	0	0
Great Crested Grebe	0	0	0.10	2	0.25	6
Cormorant	0.01	1	0	0	0	0
Little Egret	0.08	2	0.03	1	0.08	3
Oystercatcher*	0.50	4	0.38	4	1.15	32
Avocet*	2.43	28	1.04	21	0.30	19
Ringed Plover	0.44	2	1.31	30	4.85	50
Golden Plover*	2.81	23	0.03	2	0.11	6
Grey Plover	2.35	21	2.76	16	1.66	8
Lapwing	0.90	10	0.61	10	0.99	35
Knot*	7.32	80	0.64	20	1.86	66
Dunlin	22.99	191	14.78	250	15.17	200
Black-tailed Godwit*	1.46	10	0.29	20	0.24	4
Bar-tailed Godwit	0.53	3	0.29	4	0.87	6
Curlew*	2.32	10	0.93	3	0.86	4
Redshank*	5.50	12	3.08	19	2.45	14
Turnstone	0.67	6	0.49	5	0.89	18
Black-headed Gull	34.25	142	24.00	107	23.46	85
Common Gull	3.68	30	2.44	24	2.35	15
Lesser Black-backed Gull*	0.07	2	0.29	3	0.11	2
Herring Gull*	1.13	10	0.69	11	2.82	12
Great Black-backed Gull	0.13	2	0.14	2	0.10	2

Peak values are highlighted.

* – species whose numbers varied significantly between years according to GLMs (see methods).

Table 3.1.6 Mean and peak densities of waterbird species at Levington Creek (area = 1.25 ha) in the winters of 2005/06 to 2007/08.

Species	2005/06 (mean)	2005/06 (peak)	2006/07 (mean)	2006/07 (peak)	2007/08 (mean)	2007/08 (peak)
Dark-bellied Brent Goose	4.53	96.00	9.11	152.00	3.84	70.40
Shelduck	4.06	18.40	0.62	10.40	0.72	8.80
Wigeon	17.96	68.00	17.66	83.20	16.05	84.80
Teal	2.22	11.20	0.73	15.20	2.66	32.00
Mallard	0.24	1.60	0	0	0.09	1.60
Pintail	3.77	75.20	0.72	11.20	0	0
Shoveler	0	0	0	0	0	0
Great Crested Grebe	0	0	0.08	1.60	0.20	4.80
Cormorant	0.01	0.80	0	0	0	0
Little Egret	0.07	1.60	0.02	0.80	0.07	2.40
Oystercatcher	0.40	3.20	0.30	3.20	0.92	25.60
Avocet	1.94	22.40	0.83	16.80	0.24	15.20
Ringed Plover	0.36	1.60	1.04	24.00	3.88	40
Golden Plover	2.24	18.40	0.02	1.60	0.09	4.80
Grey Plover	1.88	16.80	2.21	12.80	1.33	6.40
Lapwing	0.72	8.00	0.49	8.00	0.79	28.00
Knot	5.86	64.00	0.51	16.00	1.49	52.80
Dunlin	18.39	152.80	11.82	200	12.14	160
Black-tailed Godwit	1.17	8.00	0.23	16.00	0.19	3.20
Bar-tailed Godwit	0.42	2.40	0.23	3.20	0.70	4.80
Curlew	1.86	8.00	0.74	2.40	0.69	3.20
Redshank	4.40	9.60	2.47	15.20	1.96	11.20
Turnstone	0.53	4.80	0.39	4.00	0.71	14.40
Black-headed Gull	27.40	113.60	19.20	85.60	18.77	68.00
Common Gull	2.94	24.00	1.96	19.20	1.88	12.00
Lesser Black-backed Gull	0.06	1.60	0.23	2.40	0.09	1.60
Herring Gull	0.90	8.00	0.56	8.80	2.25	9.60
Great Black-backed Gull	0.10	1.60	0.11	1.60	0.08	1.60

Peak values are highlighted.

Table 3.1.7 Percentages of each species recorded feeding at Mansbrook Grove, Pond Hall and Levington Creek over the winters 2005/06 to 2007/08.

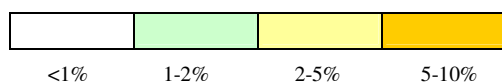
Species	Mansbrook Grove	Pond Hall	Levington Creek
Dark-bellied Brent Goose	0	0*	0.5
Shelduck	34.0	25.6	40.6
Wigeon	38.0	30.2	19.4
Teal	-	0*	57.6
Mallard	0*	0	6.7
Pintail	33.8	5.2	2.0
Shoveler			
Great Crested Grebe	-	0*	36.0
Cormorant			
Little Egret	-	100*	50.0
Oystercatcher	55.1	49.0	53.8
Avocet	-	-	69.0
Ringed Plover	100	91.7	69.1
Golden Plover	93.1	100*	40.6
Grey Plover	100	100	59.9
Lapwing	0	0*	5.6
Knot	91.9	65.6	81.8
Dunlin	84.4	98.4	94.6
Black-tailed Godwit	81.0	54.3	83.2
Bar-tailed Godwit	-	-	91.7
Curlew	81.2	84.4	90.8
Redshank	93.7	98.4	90.3
Turnstone	87.4	95.3	80.1
Black-headed Gull	1.0	1.2	0.1
Common Gull	1.4	3.3	0.2
Lesser Black-backed Gull	0	0	0
Herring Gull	1.2	1.9	3.0
Great Black-backed Gull	0	0*	3.8

* – less than 10 birds recorded.

Table 3.1.8 Comparison of the mean peak numbers of waterbirds recorded on the Mansbrook Grove mudflats between 2005/06 and 2007/08 with the mean peak numbers recorded on the Stour and Orwell Estuaries SPA by WeBS counts over the five-year period, 1995/96 to 1999/2000.

Species	Peak 2005/06	Peak 2006/07	Peak 2007/08	Mean peak 2005/06 to 2007/08	Mean peak numbers on the SPA 1995/96 to 1999/2000	Peak % of SPA individuals at Mansbrook
Dark-bellied Brent Goose	13	202	252	156	2,627	5.9
Shelduck	23	10	47	27	2,955	0.9
Wigeon	44	40	35	40	3,979	1.0
Gadwall	0	0	0	0	97	0
Pintail	40	41	18	33	741	4.5
Goldeneye	0	0	0	0	213	0
Great Crested Grebe	0	0	0	0	245	0
Cormorant	1	3	4	3	232	1.1
Ringed Plover	14	0	0	5	372	1.3
Grey Plover	7	6	3	5	3,261	0.2
Lapwing	95	32	24	50	6,242	0.8
Knot	110	35	26	57	5,970	1.0
Dunlin	138	179	46	121	19,114	0.6
Black-tailed Godwit	55	15	62	44	2,559	1.7
Curlew	18	24	14	19	2,153	0.9
Redshank	56	34	27	39	3,687	1.1
Turnstone	72	31	44	49	690	7.1

Colour coding scheme used:



SPA five-year mean of peak data are from the SPA Natura 2000 Standard Data Form (updated in May 2005).

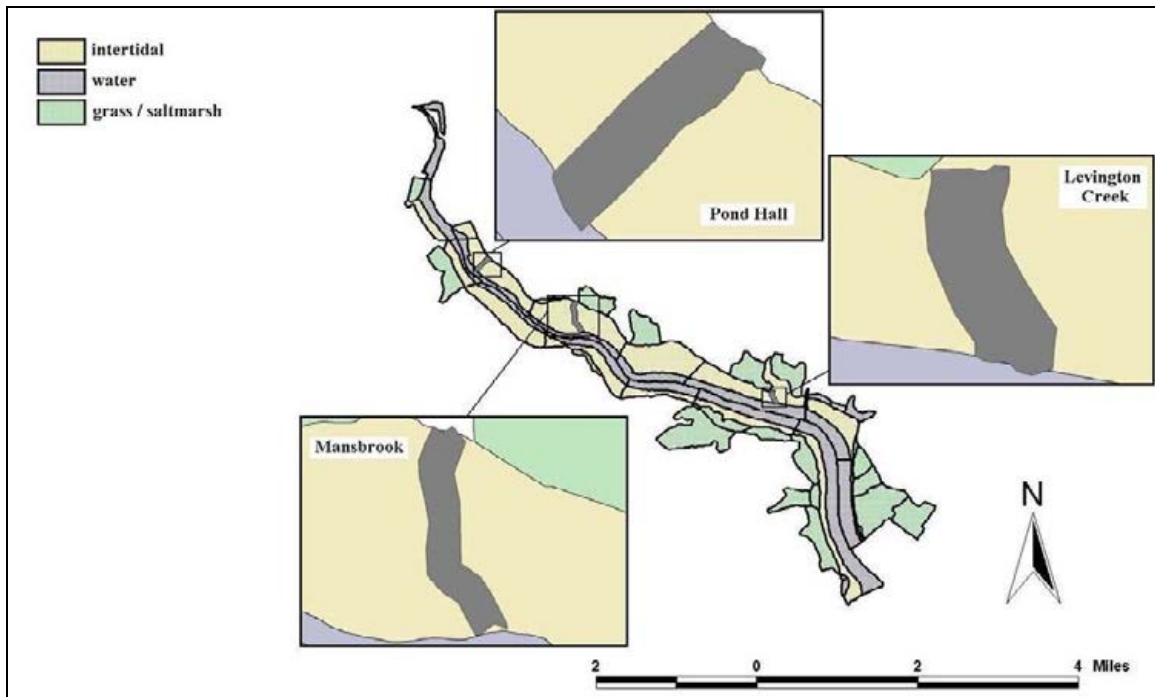


Figure 2.1.1 Map of the Orwell Estuary indicating the three broad habitat types and the boundaries of each of the sectors monitored by the Wetland Bird Survey (WeBS) Low Tide Count Scheme (Musgrove *et al.* 2003). The three areas monitored to assess the impact of the discharge of water from the proposed Ransomes Europark are shown by dark shading.

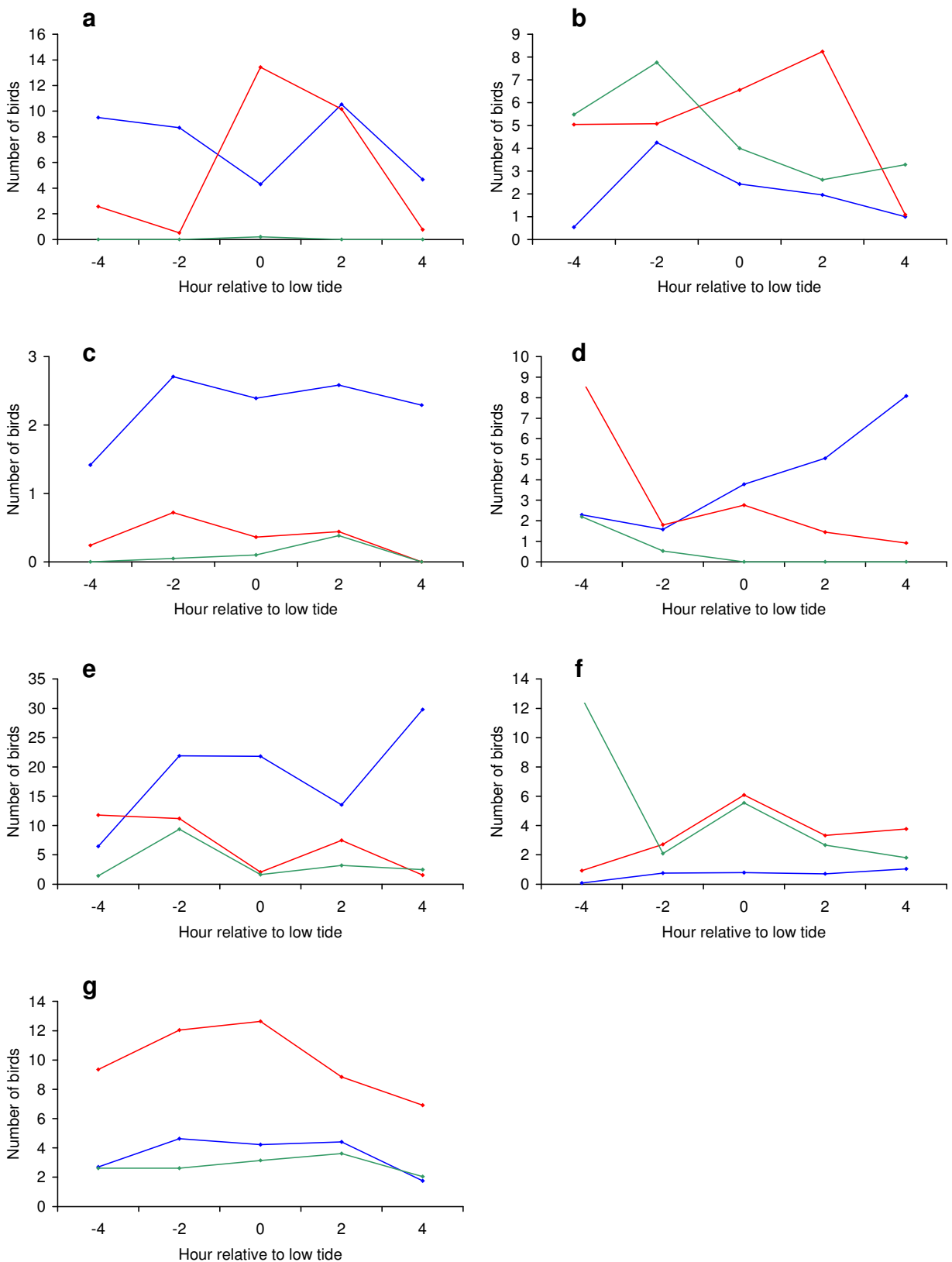


Figure 3.1.1 Variation in bird numbers recorded at Mansbrook Grove (red line), Pond Hall (green line) and Levington Creek (blue line) over the intertidal period in the winters of 2005/06 to 2007/08. Data are shown for species occurring on the Stour and Orwell Estuaries SPA in internationally important numbers. a = Dark-bellied Brent Goose; b = Pintail; c = Grey Plover; d = Knot; e = Dunlin; f = Black-tailed Godwit; g = Redshank.

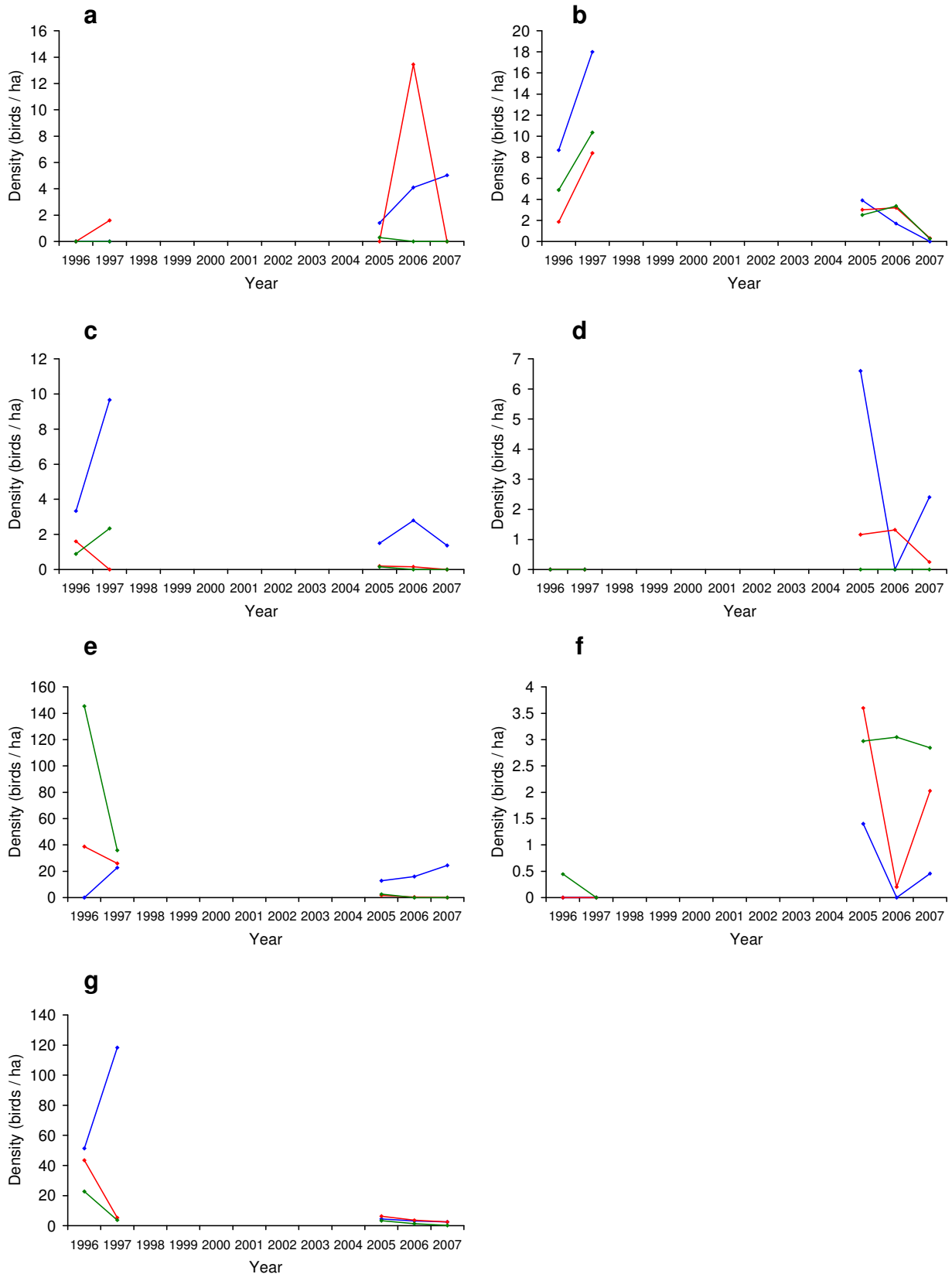


Figure 3.2.1 Densities of birds recorded at low tide at Mansbrook Grove (red line), Pond Hall (green line) and Levington Creek (blue line) in the winters of 1996/97 to 1997/98 and 2005/06 to 2007/08. Data are shown for species occurring on the Stour and Orwell Estuaries SPA in internationally important numbers. a = Dark-bellied Brent Goose; b = Pintail; c = Grey Plover; d = Knot; e = Dunlin; f = Black-tailed Godwit; g = Redshank. 1996 = 1996/97 etc. Data are from November to February each winter.

