ACTION HISTORY OF RTI REQUEST No.WLIOI/R/E/21/00071

Applicant Name	Pramod kalita
Text of Application	1) Furnished the copy Minutes of meeting held among Wildlife Institute of India, NF Railway, Forest Department govt. of Assam in 2021. 2) Furnished the copy Minutes of meeting held between NF Railway and Wildlife institute of India in 2021. 3) Furnished the copy Feasibility Study Report of Realignment of Railway track Northern periphery of Deepor Beel from km 163 to km 172 Suggested by the Wildlife Institute of India. 4) Furnished a copy of Study Report to Assess the impact of power lines on Avian Species in and around Deepor Beel Ramsar site Assam.
Reply of Application	Dear applicant, The concerned reply has been sent by email.

SN.	Action Taken	Date of Action	Action Taken By	Remarks
1	RTI REQUEST RECEIVED	19/11/2021	Nodal Officer	
2	REQUEST FORWARDED TO CPIO	24/11/2021	Nodal Officer	Forwarded to CPIO(s) : (1) Monali Sen
3	ADDITIONAL PAYMENT REQUIRED FOR INFORMATION	16/12/2021	Monali Sen-(CPIO)	an additional fee of Rs. 186.00 i.e. 93 pages @ Rs. 2/page, U/S 7(3) of RTI Act, 2005 has been requested
4	ADDITIONAL PAYMENT RECEIVED FROM REQUESTER	04/01/2022	RTI Applicant	
5	REQUEST DISPOSED OF	25/01/2022	Monali Sen-(CPIO)	

Print

By Speed Post

सूचना का अधिकार
RIGHT TO INFORMATION

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

No. WII/RTI/CPIO/2021-22 (Qtr-III)/64

Date: 24 January, 2022

To,

Mr. Pramod kalita
Vill- Chakardo, Post Office- Azara Dist- Kamrup,
Metro Assa, Guwahati-781017
Email: pramodkalita86@gmail.com

Sub.: Information under RTI Act, 2005–reg.
Ref.: Your Online RTI No. WLIOI/R/E/21/00071 dated 19/11/2021

Sir,

Please refer to your application cited above under RTI Act, 2005. In this context, the point-wise response to your queries are given below:

S. No.	Information Sought under RTI	Reply
1	Furnished the copy Minutes of meeting held among Wildlife Institute of India, NF Railway, Forest Department govt. of Assam in 2021.	Information not available
2	Furnished the copy Minutes of meeting held between NF Railway and Wildlife Institute of India in 2021.	Information not available
3	Furnished the copy Feasibility Study Report of Realignment of Railway track Northern periphery of Deepor Beel from km 163 to km 172 Suggested by the Wildlife Institute of India.	See the attached **Annexure-I** containing **25 pages**.
4	Furnished a copy of Study Report to Assess the impact of power lines on Avian Species in and around Deepor Beel Ramsar site Assam.	See the attached **Annexure-II** containing **68 pages**.

If you are not satisfied with the aforesaid reply, you may appeal to the **Dr. Dhananjai Mohan, Director & Appellate Authority, Wildlife Institute of India, Post Box 18, Chandrabani, Dehradun – 248 001, Ph. 0135-2640910.**

Thanking you,

24/1/22

EV083660062IN

O/C

Yours faithfully,

(Dr. Monali Sen, IFS)
N.O. & CPIO (RTI)

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Deepor Beel Railway Track Mitigation Plan

Mitigation measures for movement of Elephants from Rani and Garbhanga Reserve Forest to Deepor Beel across the Azara-Kamakhya Railway line in Guwahati, Assam

December, 2021

Deepor Beel Railway Track Mitigation Plan

Mitigation measures for movement of Elephants from Rani and Garbhanga Reserve Forest to Deepor Beel across the Azara-Kamakhya Railway line in Guwahati, Assam

December, 2021

WII Team

Dr. Bilal Habib
Akanksha Saxena

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

This mitigation plan was developed by Wildlife Institute of India based on request received from Northeast Frontier Railways to carry out a field visit for evaluating the suitability of the proposed mitigation measures on the second railway track vide letter No. W/362/Con/N-K/Misc./NGT; Dated 2nd July 2021.

Introduction

Deepor Beel is a perennial water-body on one of the old channels of Brahmaputra River, on the outskirts of Guwahati city. It was declared as a Ramsar site in the year 2002. The Beel attracts a plethora of resident and migrant birds and other wildlife. The lake is also an important biological and economic resource for the local people and is also a source of revenue from tourism. Pollution and encroachment along the water body have been identified as important threats to the Beel. In addition to this, the Azara-Kamakhya railway line circumventing the southern boundary of the Beel poses a barrier to the movement of wildlife, particularly elephants, that move between the Rani Reserve Forest and Deepor Beel for water.

Regular movement of elephants from Rani Reserve Forest to Deepor Beel is reported. In the year 2021 alone, 43 events of the elephant movement have been recorded by the Forest Department (Deepor Beel Wildlife Range data), comprising of individuals and small – very large herds (2-101 individuals). The Department has thus identified 6 movement corridors regularly used by elephants to access Deepor Beel.

The railway track passing through the southern boundary of Deepor Beel is an impediment to the movement of elephants that regularly visit the Beel, and 13 elephants have been killed and 5 injured due to train hits on this segment (WII, 2018[1]). Even in the absence of train-induced mortality, railway tracks impose a barrier to animal movement, and wider physical track infrastructure and increased train traffic have the potential to impede this movement. Ultimately fragments habitat and cuts off access to resources such as water. Encroachment in the intervening land between the Rani Reserve Forest and Deepor Beel has also fragmented the habitat and contiguity of the elephant movement routes in this area. Additionally, the Maghuwapara Road running almost parallel to the railway line and crossing the line at two places (level crossings at chainages 166/850 and 167/380) also poses a barrier to animal movement, especially elephants. There is also a possibility of enhancement of human-elephant conflict in the given scenario.

With respect to the issues concerning the protection and conservation of Deepor Beel, a case was filed in the National Green Tribunal (NGT), East Zone, under O.A. No.19/2014 (now O.A. No.472 of 2018) and violation of the Environment (Protection) Act, 1986 and Municipal Solid Waste (Management and Handling) Rules, 2000 in September 2014. The Northeast Frontier Railway (NFR) was made a respondent in the case citing reasons of elephant-train collision and speed restriction of 30 kmph was imposed on the trains passing through the section.

The railway line is proposed to be upgraded to a double-track line under the New Bongaigoan-Goalpara-Kamakhya doubling work (176 km). The doubling work was stopped by the NGT, East Zone, vide order dated 18.01.2018, and the NFR was directed to include mitigation measures on the railway segment to prevent potential elephant-train collisions.

On the request of the Chief Wildlife Warden of Assam, Dr. Bivash Pandav of WII had visited the site in January 2019. As per the site visit regarding mitigation measures to avoid elephant-train collisions, WII had suggested realignment of the railway track from Azara station near pillar no. 163/4 to the level crossing near Assam Engineering College at pillar no. 172/0, or the construction of a tunnel under the hilly stretch

[1] WII. 2018. Railway Lines in Elephant Habitats: With Specific reference to Deepor Beel, Assam.

between gates no. 273 and 274 in the existing railway track (vide letter No. WII/DWII/Misc./03/2018 dated 16th January 2019).

Both were found to be unfeasible from the financial and technical point of view of the railways. Subsequently, NFR has proposed the construction of the second railway track on an elevated track of 2.17 km length for elephant movement. The plan was subsequently discussed in a meeting held by the Chief Secretary, Assam, on 25th June 2021, where the Railways were directed to consult WII to examine the feasibility of the proposed measures. Northeast Frontier Railway requested WII to carry out a field visit to evaluate the feasibility of the proposed mitigation measures on both railway tracks vide letter No.W/362/Con/N-K/Misc./NGT dated 2nd July 2021.

A field visit by the WII team was subsequently carried out during 27th – 30th September 2021. The entire length of the railway track was surveyed, and the locations and structural dimensions of all proposed mitigation measures, encroachments along the railway line, and the possibility of barrier because of the Maghuwapara Road running parallel to the railway track were reviewed on the field. Consultations concerning the design, location, and dimensions were also conducted with railway officials and site engineers. Given below are our findings and recommendations.

Mitigation measures proposed by NFR

A total of four mitigation measures have been proposed by NFR, the details of which are given below (Table 1 and Figure 1). The height of all structures is >= 7 m.

Table 1. Details of mitigation measures proposed by NFR on the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	Structure Type	Structure width (m)	Chainage (km)
1.	RCC	200	164/000 – 164/200
2.	RCC	100	164/500 – 164/600
3.	RCC	100	165/200 – 165/300
4.	Viaduct	3500	165/400 – 168/900

In addition to these structures, segment-wise recommendations to mitigate the combined barrier effect of double railway track and Maghuwapara road are provided in the sections below. Underpasses on the road sections parallel to the underpasses on the railway track and guide walls are recommended in order to:

a. enhance the efficacy of the railway underpasses,
b. direct animal movement towards underpasses, and
c. mitigate human-elephant conflict in the long-term.

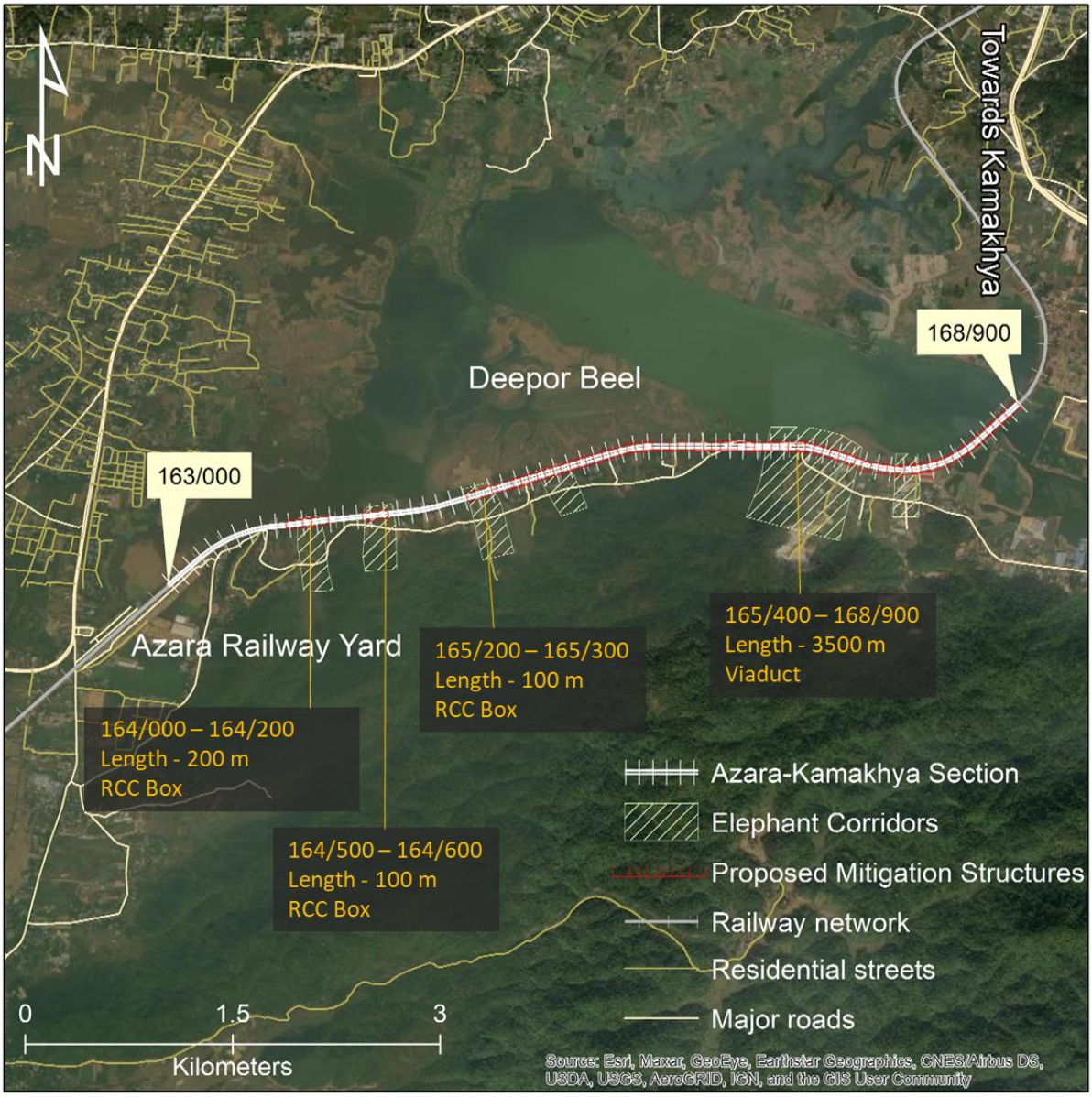

Figure 1. Railway track, elephant corridors and mitigation measures proposed by NFR for doubling of railway track between Azara – Kamakhya (Chainage 163/000 – 168/900) passing through the southern boundary of Deepor Beel, Guwahati, Assam.

1. Chainage 164/000 – 164/200

One mitigation structure (RCC box) measuring 200 m wide and 7 m high has been proposed on the first corridor (Chainage 164/000 – 164/150). Additionally, an underpass measuring 150 m wide and 7 m high on the road parallel to the railway track is recommended. It is also recommended to install guide walls to direct animal movement first towards the road underpass and then towards the railway track underpass***. It is recommended to construct the underpasses as RCC structures with a span of 12 m and pillar-type divisions.*** The details of the proposed and recommended mitigation measures are provided in Table 2 and Figure 2.

Table 2. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 164/000 – 164/200 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	Mitigation Measure	Chainage/GPS location	Dimensions (m) *Width x height*
1.	Underpass on railway track	164/000 – 164/200	200 x 7
2.	Underpass on road	Start: 26° 6'19.29"N 91°37'43.23"E End: 26° 6'17.33"N 91°37'39.70"E	150 x 7
3.	Guide walls	.kml provided (I.GW1 & I.GW2)	570 (west side) 220 (east side)

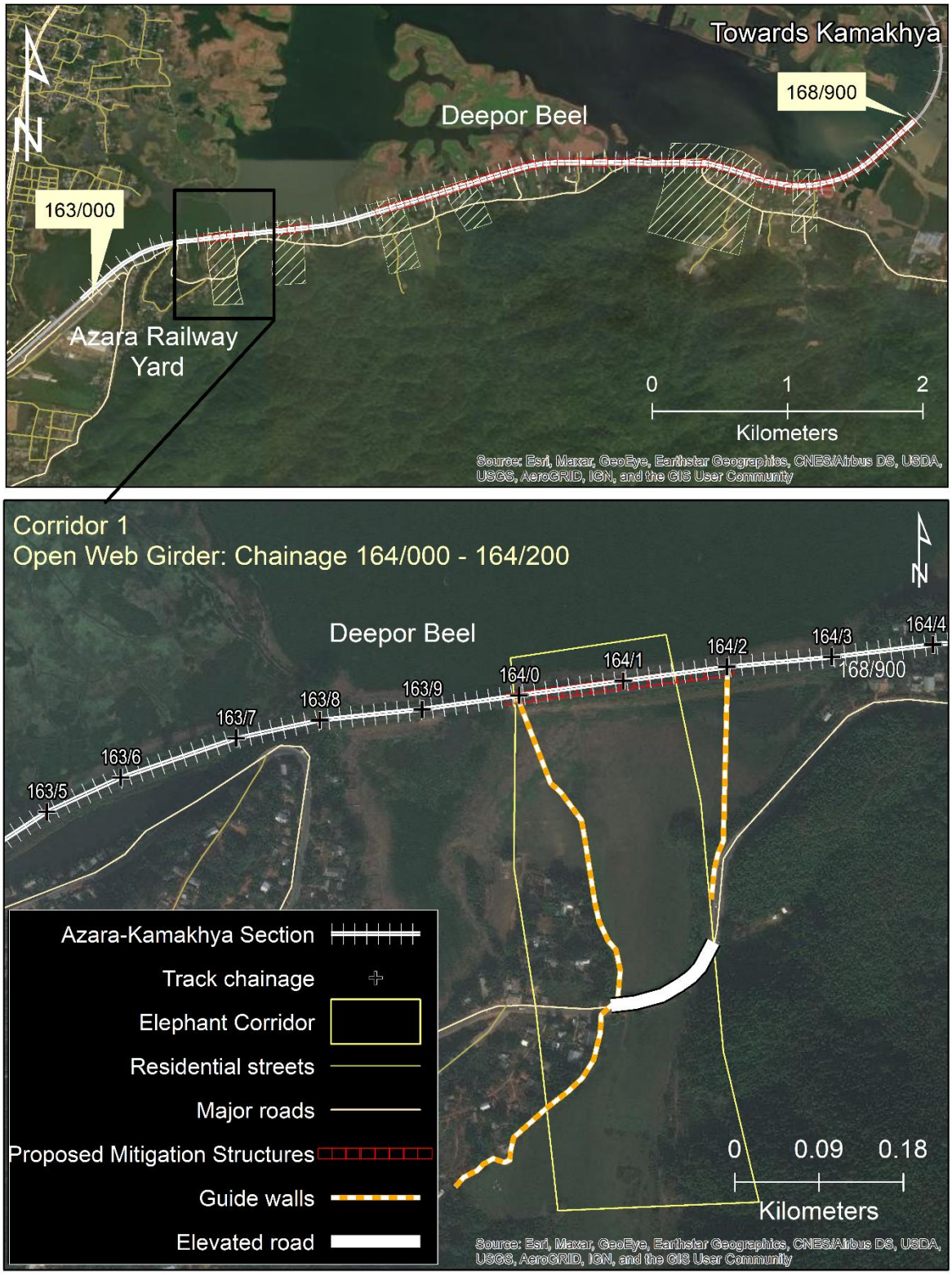

Figure 2. Railway track, elephant corridors and mitigation measures proposed by NFR and recommended by WII for doubling of railway track between chainage 164/000 – 164/200 of the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

2. Chainage 164/500 – 164/600

One mitigation structure (RCC box) measuring 100 m wide and 7 m high has been proposed on the second corridor (Chainage 164/400 – 164/600). Additionally, an underpass measuring 100 m wide and 7 m high on the road parallel to the railway track is recommended. It is also recommended to install guide walls to direct animal movement first towards the road underpass and then towards the railway track underpass. ***It is recommended to construct the underpasses as RCC structures with a span of 12 m and pillar-type divisions.*** The details of the proposed and recommended mitigation measures are provided in Table 3 and Figure 3.

Table 3. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 164/500 – 164/600 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	**Mitigation Measure**	**Chainage/GPS location**	**Dimensions (m)** *Width x height*
1.	Underpass on railway track	164/500 – 164/600	100 x 7
2.	Underpass on road	Start: 26° 6'25.71"N 91°37'58.73"E End: 26° 6'26.24"N 91°37'55.24"E	100 x 7
3.	Guide walls	.kml provided (II.GW1 & II.GW2)	246 (west side) 146 (east side)

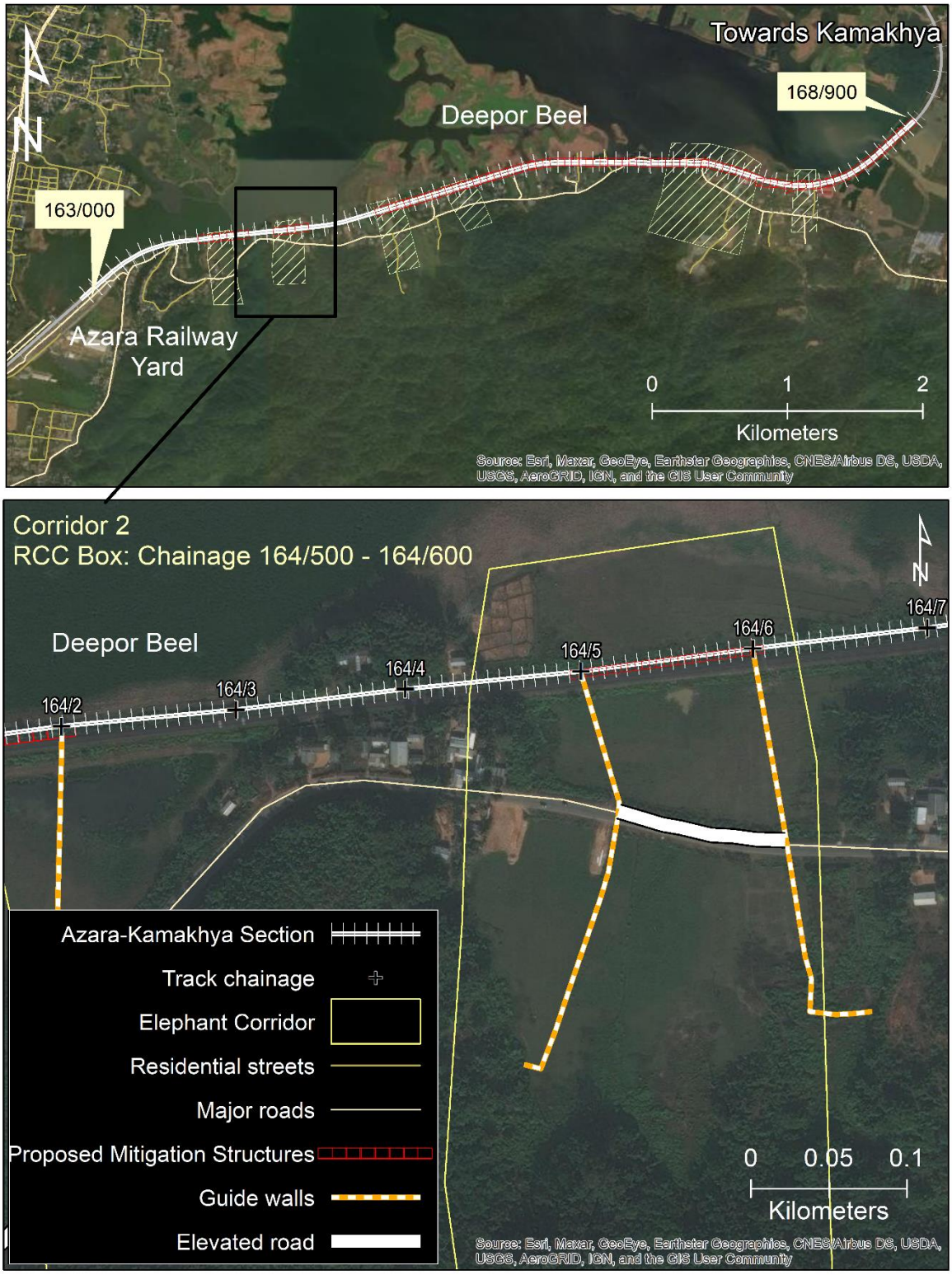

Figure 3. Railway track, elephant corridors and mitigation measures proposed by NFR and recommended by WII for doubling of railway track between chainage 164/500 – 164/600 of the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

3. Chainage 165/200 – 165/300

One mitigation structure (RCC box) measuring 100 m wide and 7 m high has been proposed on the third corridor (Chainage 165/100 – 165/300). Additionally, an underpass measuring 100 m wide and 7 m high on the road parallel to the railway track is recommended. It is also recommended to install guide walls to direct animal movement first towards the road underpass and then towards the railway track underpass. ***It is recommended to construct the underpasses as RCC structures with a span of 12 m and pillar-type divisions***. The details of the proposed and recommended mitigation measures is provided in Table 4 and Figure 4.

Table 4. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 165/200 – 165/300 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	**Mitigation measure**	**Chainage/GPS location**	**Dimensions (m)** *Width x height*
1.	Underpass on railway track	165/200 – 165/300	100 x 7
2.	Underpass on road	Start: 26° 6'30.08"N 91°38'26.67"E End: 26° 6'29.05"N 91°38'23.64"E	100 x 7
3.	Guide walls	.kml provided (III.GW1 & III.GW2)	537 (west side) 370 (east side)

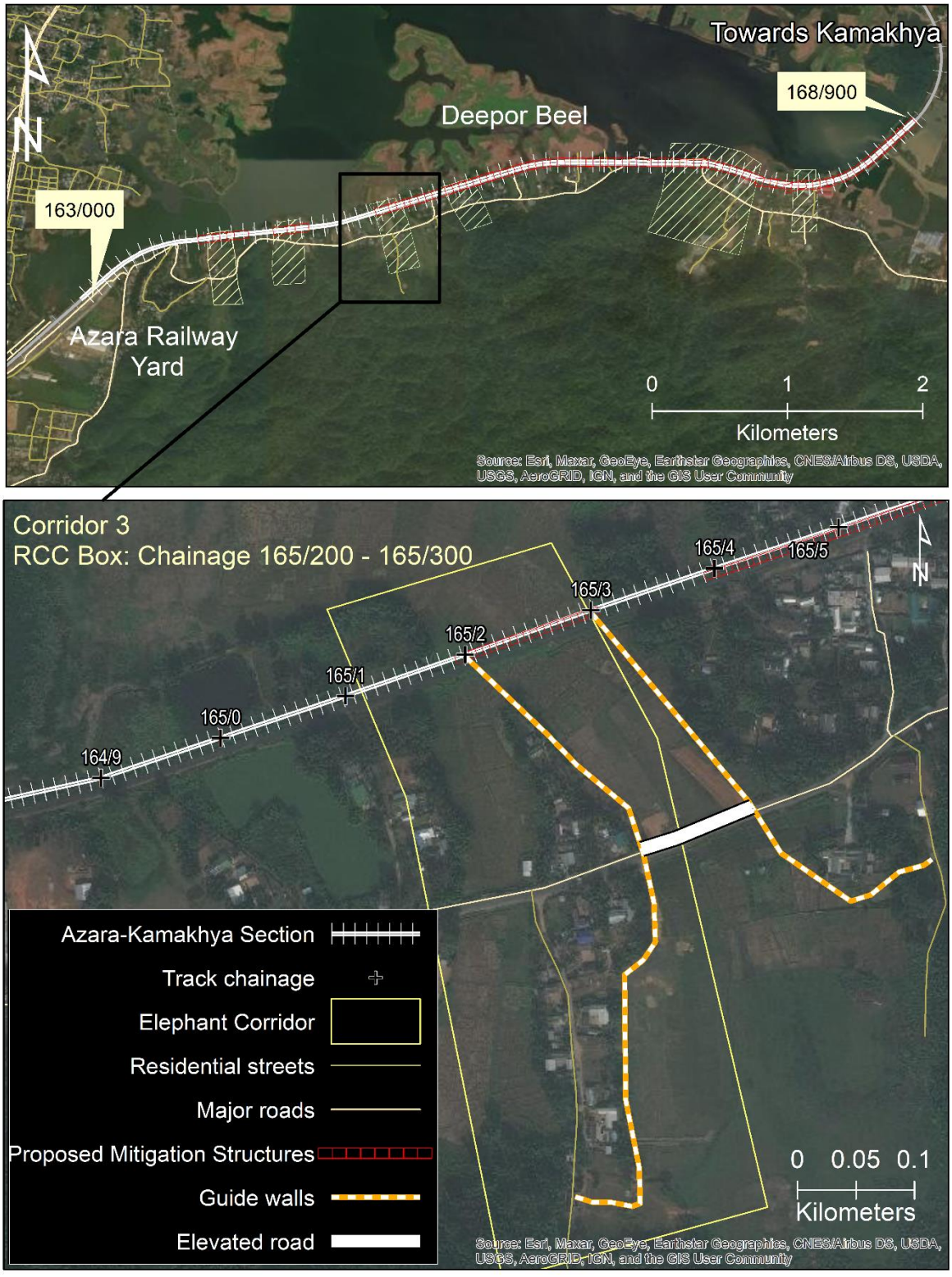

Figure 4. Railway track, elephant corridors and mitigation measures proposed by NFR and recommended by WII for doubling of railway track between chainage 165/200 – 165/300 of the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

4. Chainage 165/400 – 168/900

One mitigation structure (viaduct) measuring 3500 m wide and 7 m high (Figure 5) has been proposed on this section. The viaduct covers three designated elephant corridors (Chainage 165/600 – 165/800, 167/100 – 167/700 and 168/000 – 168/150). The details of the proposed and recommended mitigation measures are provided in Table 5 and Figure 5.

Table 5. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 165/400 – 168/900 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	Mitigation measure	Chainage/GPS location	Dimensions (m) *Width x height*
1.	Viaduct on railway track	165/400 – 168/900	3500 x 7

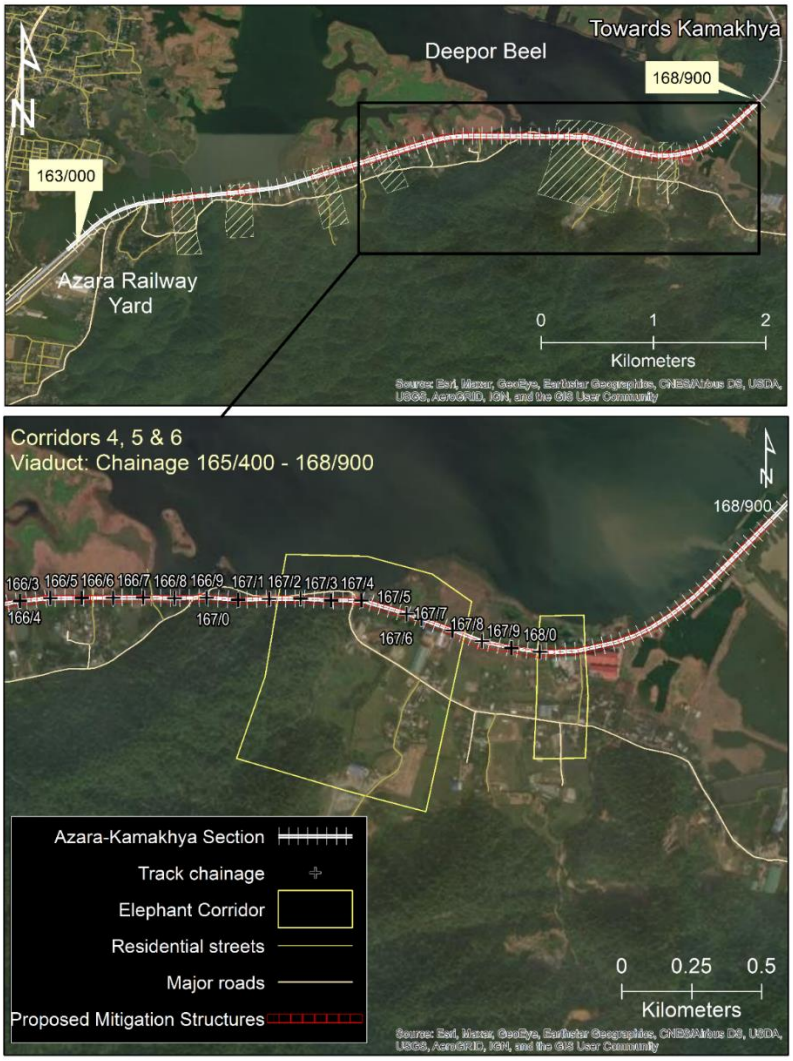

Figure 5. Railway track, elephant corridors and mitigation measures proposed by NFR and recommended by WII for doubling of railway track between chainage 165/400 – 168/900 of the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

Additional recommendations have been made specifically for the three segments that fall near or within the designated elephant corridors.

A. Section between chainage 165/950 – 166/050

An underpass measuring 100 m wide and 7 m high on the road parallel to the railway track is recommended. It is also recommended to install guide walls to direct animal movement first towards the road underpass and then towards the viaduct on the railway track. The details of the proposed and recommended mitigation measures is provided in Table 6 and Figure 6.

Table 6. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 165/930 – 166/050 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	Mitigation measure	GPS location	**Dimensions (m)** *Width x height*
1.	Underpass on road	Start: 26° 6'36.21"N 91°38'50.49"E End: 26° 6'36.38"N 91°38'46.70"E	100 x 7
2.	Guide walls	.kml provided (IV.GW1 & IV.GW2)	270 (west side) 336 (east side)

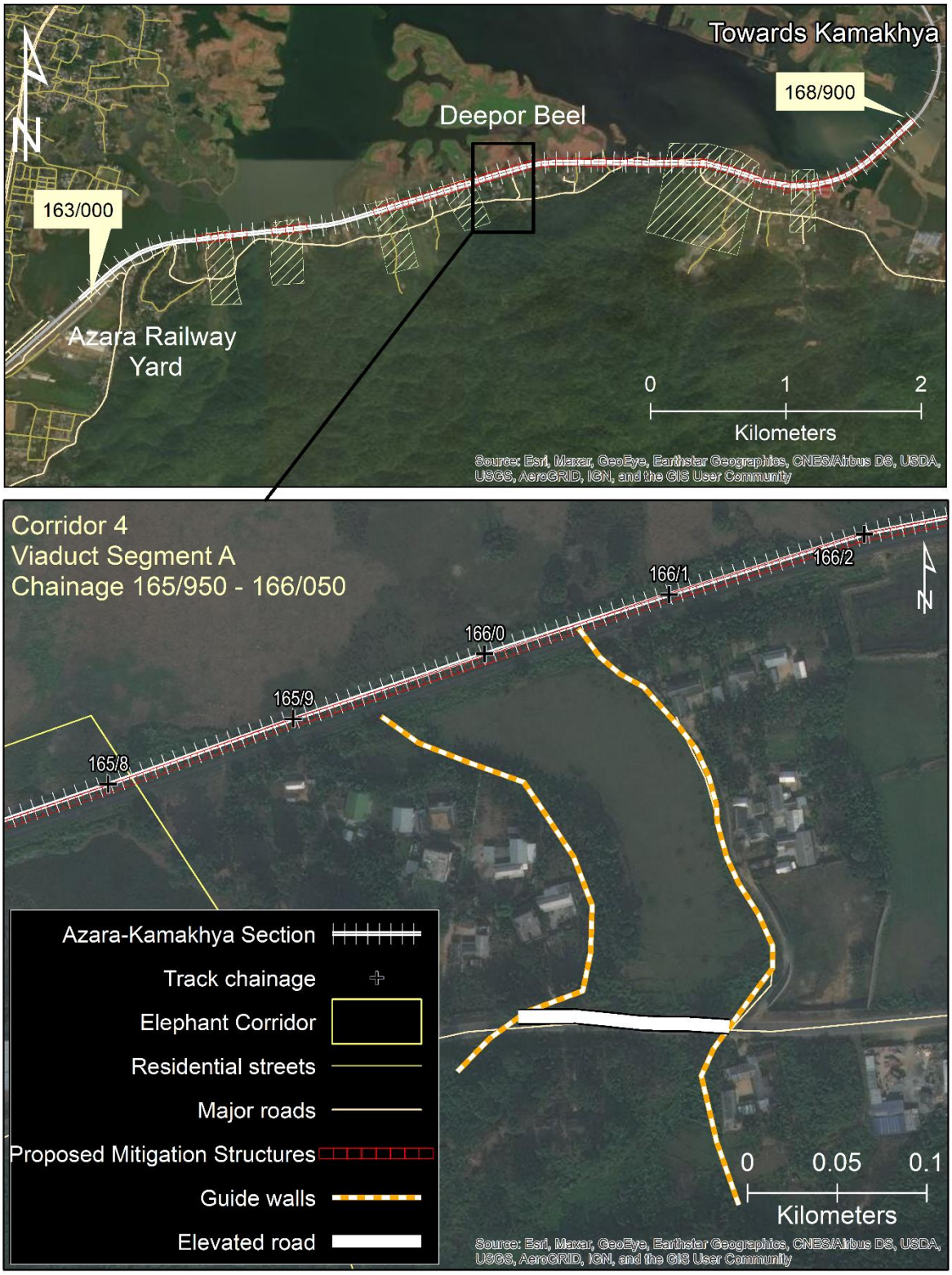

Figure 6. Additional mitigation measures recommended in the first segment (chainage 165/950 – 166/050) of the 3500 m ling viaduct on the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

B. Section between chainage 166/850 and 167/380

It is recommended to elevate the road section between the two level crossings (chainages 166/850 and 167/380) presently crossing over to the north of the railway track (Figure 7). The road must be elevated and brought to the south of the present alignment. The length of the road between the two level crossings is 520 m. The height of the road underpass should be the same as that of the viaduct for the entire stretch (7 m). The details of the proposed and recommended mitigation measures is provided in Table 7 and Figure 7.

Table 7. Details of mitigation measures proposed by NFR and recommended by WII on Chainage 166/850 – 167/380 of the Azara-Kamakhya section of railway line passing through Deepor Beel, Guwahati, Assam

S. No.	Mitigation measure	Chainage/GPS location	**Dimensions (m)** *Width x height*
1.	Underpass on road	166/850 – 167/380 Start: 26° 6'45.16"N 91°39'16.56"E End: 26° 6'44.74"N 91°39'35.09"E	520 x 7

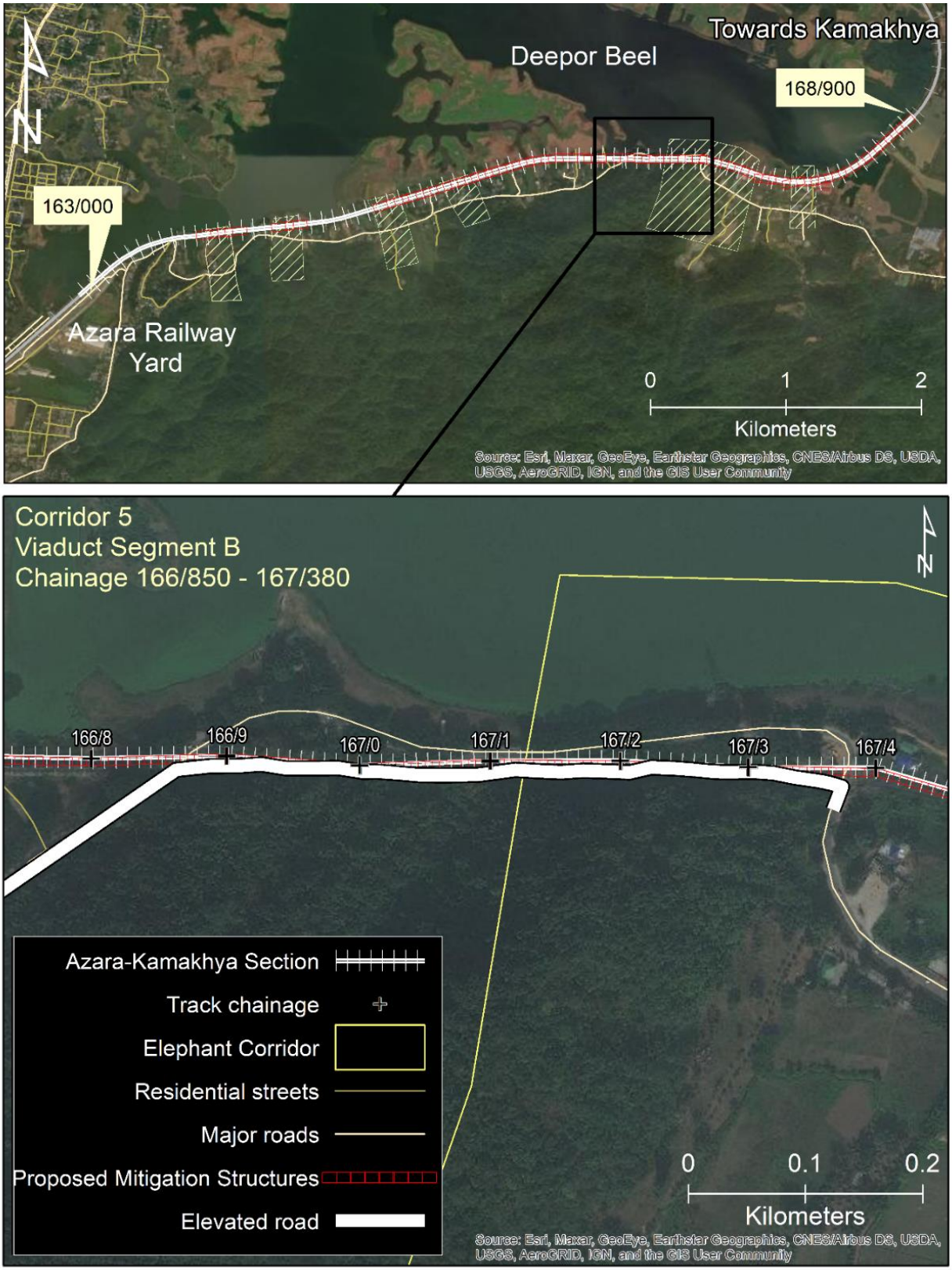

Figure 7. Additional mitigation measures recommended in the second segment (chainage 166/850 – 167/380) of the 3500 m ling viaduct on the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

C. Section between chainage 167/380 and 168/130

An attempt to remove all encroachments falling in the area should be made (Figure 8). This stretch has two critical elephant corridors and if the encroachments are not removed, all mitigation measures would be futile.

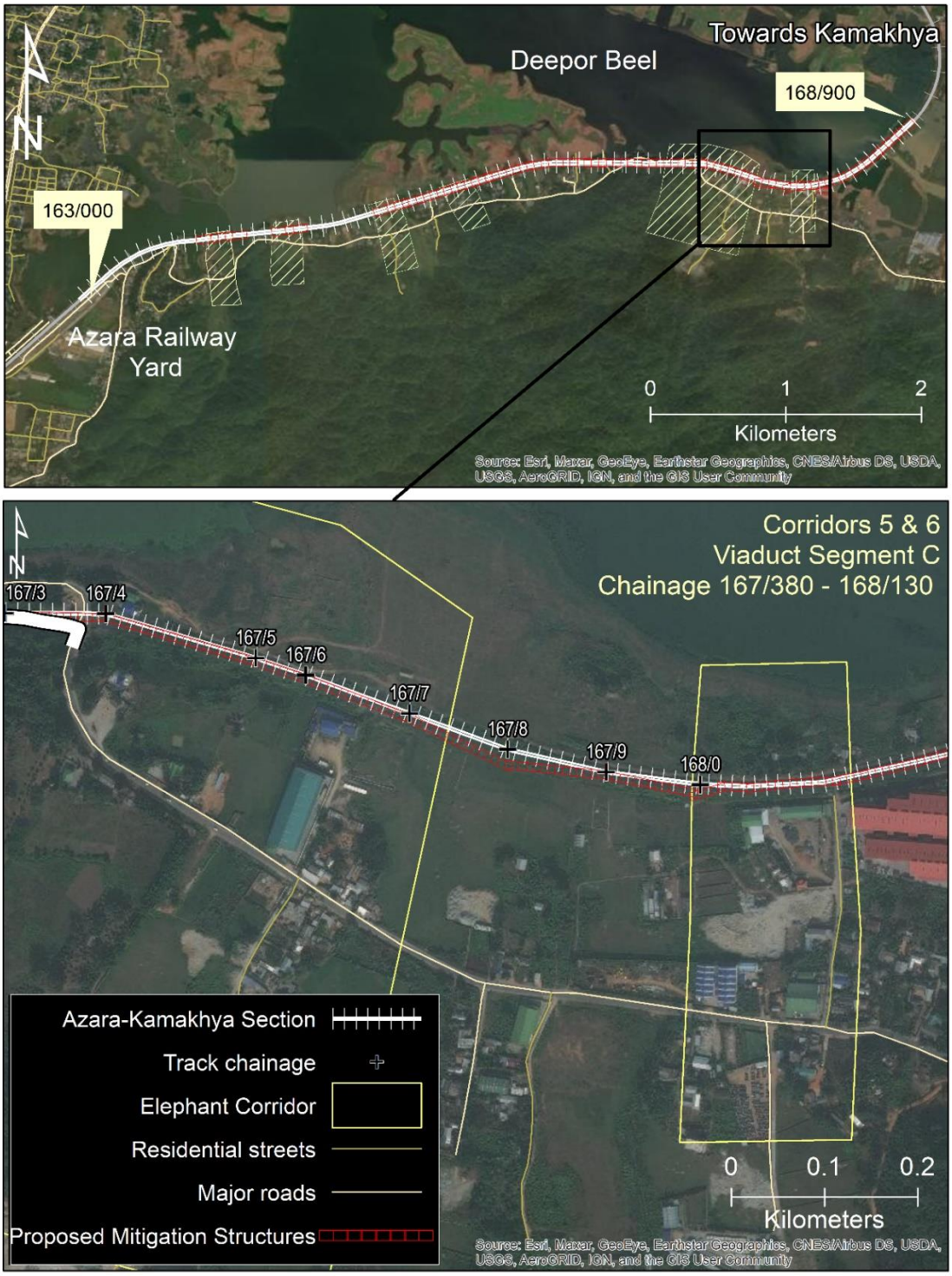

Figure 8. Additional mitigation measures recommended in the third segment (chainage 167/380 – 168/130) of the 3500 m ling viaduct on the Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

Summary of Mitigation Measures

Overall, 4 mitigation measures are recommended on both railway tracks, and 5 on the Maghuwapara road. The details of all measures are provided in Table 8.

Table 8. Summary of mitigation measures recommended on Azara – Kamakhya railway line passing through the southern boundary of Deepor Beel, Guwahati, Assam.

S. No.	Mitigation measure	Chainage/GPS location	Dimensions (in m) *Width x height*
1.	RCC box culvert	164/000 – 164/200	200 x 7
2.	Underpass on road	Start: 26° 6'19.29"N 91°37'43.23"E End: 26° 6'17.33"N 91°37'39.70"E	150 x 7
3.	Guide walls	.kml provided	570 (west) 220 (east)
4.	RCC box culvert	164/500 – 164/600	100 x 7
5.	Underpass on road	Start: 26° 6'25.71"N 91°37'58.73"E End: 26° 6'26.24"N 91°37'55.24"E	100 x 7
6.	Guide walls	.kml provided	246 (west) 146 (east)
7.	RCC box culvert	165/200 – 165/300	100 x 7
8.	Underpass on road	Start: 26° 6'30.08"N 91°38'26.67"E End: 26° 6'29.05"N 91°38'23.64"E	100 x 7
9.	Guide walls	.kml provided	537 (west) 370 (east)
10.	Viaduct	165/400 – 168/900	3500 x 7
10A.	Underpass on road	Start: 26° 6'36.21"N 91°38'50.49"E End: 26° 6'36.38"N 91°38'46.70"E	100 x 7
	Guide walls	.kml provided	270 (west) 336 (east)
10B.	Underpass on road	166/850 – 167/380 Start: 26° 6'45.16"N 91°39'16.56"E End: 26° 6'44.74"N 91°39'35.09"E	520
10C.	Removal of encroachments	167/380 – 168/130	

It is again highlighted that the encroachments along the railway track especially along the elephant movement corridors need to be removed to enhance the functionality of the proposed structures and to reduce the possibility of human-elephant conflict.

General Recommendations:

i. Guide walls are recommended to direct animal movement towards the underpasses.
ii. The width of individual spans on all crossing structures (road and railway) should be 12 m wide (instead of 5 m wide RCC box).
iii. The divisions of the crossing structures measuring 100 – 200 m should be of pillar type (instead of wall-type, Figure 9 a and b) with 1.5 m diameter.

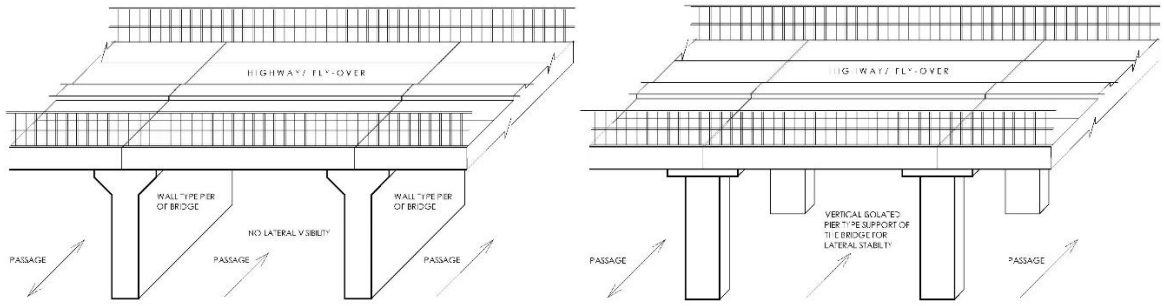

Figure 9 (a) Wall-type division of bridge and (b) pillar-type division

iv. Attempts should be made to remove encroachments on forest land between Rani Reserve Forest and Deepor Beel for maintaining elephant movement in the area.
v. The existing railway bed should be removed, and the height of the track should be taken from the ground level (not from the existing trackbed level).
vi. The spacing between two railway tracks should be as open and wide as possible. The gap between tracks on crossing structure sections should be of open type (Figure 10).

Figure 10. Gap between two parallel bridges (Image: internet)

vii. The height of all crossing structures (road and railway line) is to be 7 m for the passage of elephant herds.
viii. The underpasses must be kept free of all human-related activities including foot trails and minor roads, as these have a negative influence on the use and crossing rates of animals.

Mitigation measures on the adjoining road:

The mitigation measures on the proposed double railway track are only going to be effective if the adjoining roads are also mitigated. We have already suggested mitigation measures on adjoining road stretches along with guide walls. All these measures will help in the effective utilization of Deepor Beel by elephants especially during water scarce situations and will also reduce human-elephant interactions. The height of all animal crossing structures on the road should be 7 m, and the divisions should be pillar-type instead of wall-type (Fig. 9a). The mitigation measures should be considered as a part of complete Mitigation Plan.

Encroachment along Deepor Beel:

There are a lot of encroachments along the Deepor Beel. An increase in encroachments shall not only result in enhanced human-elephant interaction but will also reduce the water-catchment area of the Beel. It is recommended to remove all the encroachments along the forest edge and along railway track to enhance use by elephants, especially along the identified elephant movement corridors.

Speed restrictions:

The prevalent restrictions imposed on train speed will continue as such. The restrictions would automatically be removed once the mitigation measures are in place for both the railway tracks.

Electrifications of the existing track:

Since the existing railway track is on an elevated bank, elephants have to cross while accessing water from the Beel. This may render electrified railway track riskier to elephant movement. Therefore, the possibility of electrification of the existing railway track should not be considered. Once the mitigation measures are in place, the railway tracks may be electrified all along the Beel. The railway tracks on either side need to be fenced (elephant proof fence) in areas where mitigation measures are not in place to avoid incidents of electrocution and rail hit.

Use of technological options:

It is recommended to explore the possibility of using technological options such as “Optical Fibre Sensing”, “Seismic Sensors”, etc., for detecting animals along the railway track for early warning. The system should have the capability to align with the existing signaling system of railways to avoid the hit/death of elephants or humans or damage to railways. This system should be deployed along the railway track in areas where there are no mitigation measures to avoid loss of human and animal life.

Wildlife Institute of India
Chandrabani, Dehradun, India 248 001
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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Study to assess the impact of Power lines on Avian Species in and around Deepor Beel Ramsar Site, Assam

TR No. 2021/12

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Front Cover Image: Greater Adjutant © Kartik Patel
Transmission line at Deepor Beel © Dipanjali Gohain

Back Cover Image: Falcated Duck © Harindra Baraiya

Study to assess the impact of Power lines on Avian Species in and around Deepor Beel Ramsar Site, Assam

Technical Report

submitted to the

Assam State Forest Department

September 2021

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Project Brief and Project Personnel

Project Title	Study to assess the impact of power lines on avian species in and around the Deepor Beel Ramsar Site, Assam
Name and Address of the Reporting Institute	Wildlife Institute of India P.O. Box # 18, Chandrabani Dehradun- 248001 (Uttarakhand), India
Project Start Date	15 December 2020
Project Duration	8 Months
Name of the Investigator	Dr. R. Suresh Kumar, Scientist – E Dr. Dhananjai Mohan, IFS, Director
Research Personnel	Ms. Dipanjali Gohain
Inputs From	Mr. Dhiraj Das Mr. Gaurav Sirola Mr. Harindra Baraiya
Funding Agency	Assam State Forest Department

Citation

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Contents

Summary

This report details the findings of the study on an assessment of the impact of power lines on birds in and around the Deepor Beel Ramsar site. This is the first such study at this site and was taken up following a request from the Assam State Forest Department. The study determined areas in the Beel with high diversity and abundance of select avian species groups, specifically those that are known to be impacted by power lines. Additionally, the power lines both transmission and distribution lines in the area were mapped and characterized, and also assessed for their collision and electrocution risk to birds. Only one 220 kV transmission line spanning a length of 11 km was in the area that passed all along the southern fringe of the Beel, while 30 distribution lines spanning a total length of 55 km were located in and around the Beel that included 28 lines of 11 kV and 2 lines of 33 kV capacities. The distribution line power poles (1000 of 11 kV and 333 of 33 kV) based on their structural design were assessed in terms of their potential electrocution risk as from very high to low or no risk.

A total of 120 bird species were recorded during the study that included 67 species potentially impacted by power lines. Of these, 40 species were those prone to collision risk, 21 to electrocution risk and six to both. The eastern parts of the Beel had maximum number of waterbirds, a majority of which were migratory ducks and geese, while water associate species like storks, herons, ibis, egrets and others were found maximum in the western parts of the Beel. Waterbirds in the area appeared to potentially face a lesser risk of collision with the transmission line as the areas where they primarily occurred were quite distant, on an average 2 km away. The water associates on the other hand particularly the threatened Greater and Lesser Adjutant likely face either collision and or electrocution risk as they were recorded from across the Beel, and also that they particularly congregated in very large numbers in and around the Boragaon disposal site.

Collision risk assessment based on observations of birds in flight crossing the transmission line in the area identified select spans, specifically one passing over a water expanse to pose relatively higher risk to birds. It was also here that maximum number of dangerous flights by birds while attempting to cross the transmission line span was observed. The extensive mortality surveys to assess electrocution risk by distribution line power poles in the area lead to finding a single case of Greater Adjutant *Leptoptilos dubius* electrocution. The Adjutant stork was electrocuted on a 33 kV power pole located in a forested tract of the Rani-Garbhanga Reserve Forest along the southern fringe of the Beel. The distribution line section there appears to pose serious risks to Adjutant storks as the birds were observed to shuttle between their day roost in the Reserve Forest to the Beel or to the disposal site. The 33 kV pole design having longer cross arms (2 to 3 meter), placed horizontally at the top of the pole provided ideal platform for large birds to perch, and poles like these with exposed phase and jumper wires were found to pose very high electrocution risk to birds.

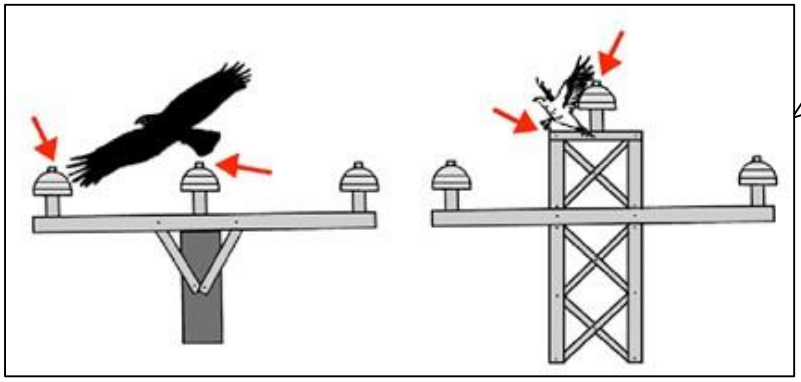
To summarize, this study as required identified high use areas by avian species groups, identified high-risk transmission line stretches and problematic distribution power poles posing collision, and electrocution risk to birds in the area specifically of the Adjutant storks in and around the Beel. And, lastly measures to mitigate or minimize the risks posed by the power lines to birds in the area is provided.

Introduction

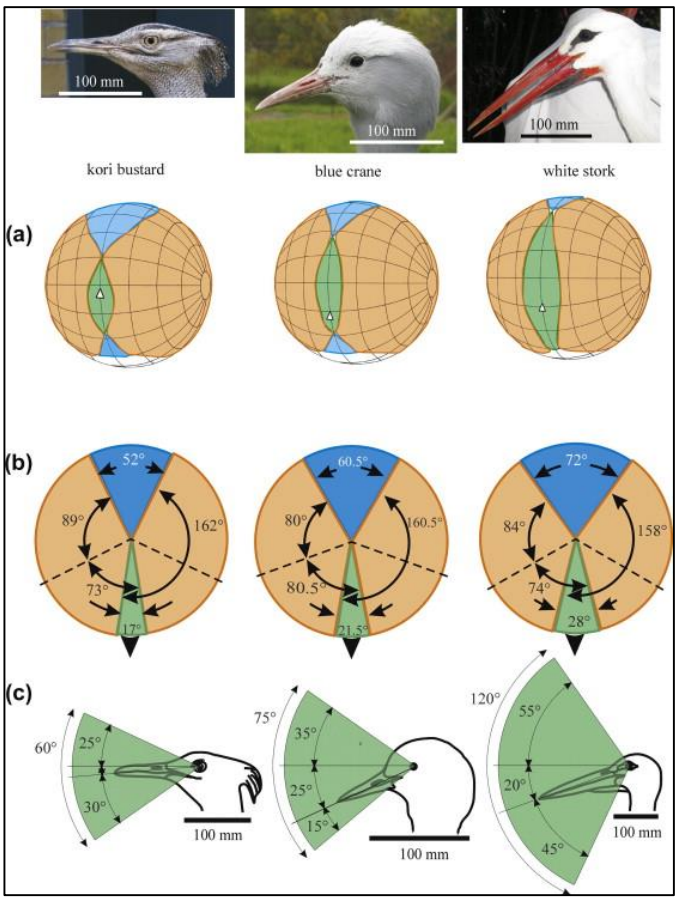
Globally collisions with power lines and electrocutions are said to cause more than one billion annual bird mortalities (Hunting, 2002). This extent of mortality would rank power lines along with wind turbines and communication towers to be a major threat to birds (Longcore et al. 2012; Smallwood, 2013). Furthermore, mortality at power lines may contribute to population declines for some species, as evidenced by studies documenting that power line-caused mortality can cause a large percentage of total mortality for species from several avian orders (Bevanger, 1995; Sergio, 2004; Sundar & Choudhury, 2005; Harness et al. 2013; Hernández-Matías et al. 2015; Shobrak et al. 2021; Uddin et al. 2021).

Birds can safely sit on energized equipment on a power line as long as all points of contact are at the same electric potential. Death (electrocution) or injury (shock) occurs only when birds create a circuit through which electric current flows from a higher potential (or voltage) to a lower potential (often a path to ground). This can occur if a bird simultaneously contacts two differently energized wires (phase wires) or simultaneously contacts an energized wire and any grounded, conductive material. On the other hand, transmission lines are primarily

associated with collision of birds and most often with the overhead static wire (earth wire), which has a smaller diameter as compared to the energized conductors making it less visible, and affects selected group of large birds like storks, cranes and bustards whose field of vision is narrow towards the front due to their sidewise eye placement, thereby lacking the ability to quickly negotiate obstacles, making them more vulnerable to power line collisions (Martin and Shaw, 2010).



Structural design of the power poles in distribution lines such as separation distances between conducting surfaces as show in the image dictates electrocution risks to birds. (Source: Tinto et al. 2005)



Large birds such as storks, cranes and bustards are prone to collision risk with power lines when in flight due to their lateral position of eyes resulting in a narrow frontal visual field and differ in the extent of the blind areas which project above and below their binocular fields (Source: Martin and Shaw 2010)

Electrocution and collision of birds due to power lines is a topic of conservation priority and a matter of serious economic and financial cost due to disruption to power supplies, consequently becoming a cause of concern to electricity-producing and distribution companies. Though, appropriate routing and structural design of power-lines is said to reduce the risks posed to birds by 50% or more (Jenkins et al. 2010; Prinsen et al. 2012). A large number of studies world over have focused on this issue and guidelines or measures to mitigate or reduce the risks posed by power lines have been developed and implemented at both the local level as well as globally. Few of these guidance documents include those developed by the Avian Power Line Interaction Committee (APLIC) (2006, 2012, 2015), Prinsen et al. (2012), Raptor Protection of Slovakia (2019), and WII (2016) for the Indian region.

Electricity generated at power stations is transmitted by high voltage long distance transmission lines to the distribution centers and these lines traverse through landscapes across the country that are generally rich in wildlife. Power lines are also aligned through ecologically sensitive areas and through forests, National Parks and Wildlife Sanctuaries that often require diversion of forest land. Current and future patterns of electric power transmission and distribution lines across the country will increase the potential for interference with the daily, seasonal movements of both resident and migratory birds. Habitats and flight pathways of birds are unavoidably altered by the presence of overhead power-lines and associated structures. Migration and distribution patterns are also affected if the birds avoid areas adjacent to these structures. However, the overall impact of power-lines on bird movements is not fully understood, although it has been the subject of an increasing amount of research in recent years.

In a similar context, the Assam State Forest Department requested Wildlife Institute of India (WII) to undertake a study to ascertain the impact of power lines passing through Deepor Beel to avifauna (Letter No. WL/FG. 35/Deepor Beel Conservation & Development Society/2019 dated 18th July 2019). Deepor Beel is a large freshwater lake and an important riverine wetland in the Brahmaputra valley of lower Assam. The wetland was declared as a Ramsar site in 2002

since it is known to harbor large congregations of resident and migratory Waterbirds, and also that it supports high floral and faunal diversity. Located close to the Guwahati city, this site is reported to face a number of threats specifically due to over-fishing, hunting of waterbirds, pollution from pesticides and fertilizers, release of sewage into the lake, dumping of solid waste, invasion of water hyacinth *Eichhornia crassipes,* and human encroachment (RIS, 2002, Anonymous, 2008). Added to this is the increase in power line network around the wetland. Therefore, to ascertain the impact of power lines on birds at the Deepor Beel Ramsar site a short-term study from December 2020 to May 2021 was taken up. The study aimed at determining the spatial distribution of select avian species of conservation significance in the wetland, and monitor and assess the impact on avifauna due to the existing power lines in and around the wetland.

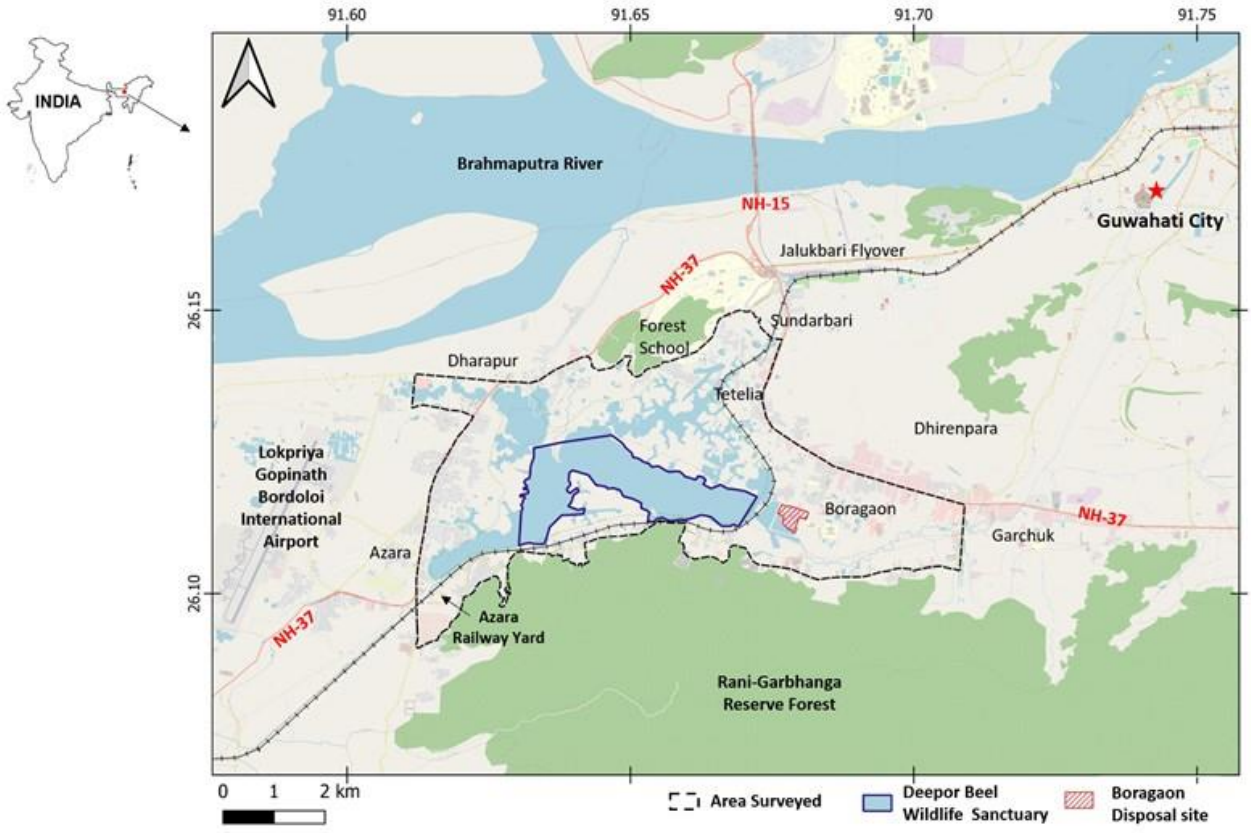
Deepor Beel Ramsar Site

Deepor Beel declared as a Ramsar site in 2002 is located south-west of the Guwahati city and is the largest riverine wetland in the Brahmaputra valley in the Assam State. Various sources quote the area of Deepor Beel differently although the Guwahati Metropolitan Development Authority has identified this as 21.4 sq.km from the highest flood level. The notified area of Deepor Beel wetland as per Guwahati Water Bodies (Preservation & Conservation) Act, 2008 is 6.89 sq. km and includes the core area of 4.1 sq.km as Deepor Beel Wildlife Sanctuary (Final Notification issued vide. no. FRM. 140/2005/260 dated 21/02/2009), and is depicted in Figure 1. This wetland is fed by the rivers Basistha and Kalamani, and from local monsoon runoff; and drains out from the north to the Brahmaputra river through a channel. The wetland is characterized by both deep open water, and shallow marshy and grassland patches. During the monsoon the water level in the wetland is known to rise to about 4 meters, while during winter the drier phase it drops to one meter resulting in large parts of the wetland drying up (RIS, 2002). The Beel is bounded by the hills of the Rani-Garbhanga Reserve Forests along the southern fringe, while on other sides is surrounded by several villages, urban clusters and industrial establishments including a railway yard located at the south-western corner.

Detailed information on the floral and faunal elements recorded in the wetland are given in RIS (2002). However, specifically to state the floral diversity of this wetland is primarily water hyacinth, aquatic grasses, water lilies and other submerged, emergent and floating vegetation. A number of threatened mammalian fauna are recorded from the hills and include the Asian Elephant *Elephas maximus*, populations of which regularly move down from the hills to the wetland during the dry period to forage on the aquatic plants. The wetland is very famous for its avifauna, particularly known for the large congregations of resident and migratory Waterbirds, and has been identified as an Important Bird Area (BirdLife International, 2021). A number of globally threatened bird species are recorded here including the Critically Endangered Baer's Pochard *Aythya baeri,* White-rumped Vulture *Gyps bengalensis and* Slender-billed Vulture *Gyps tenuirostris.* The other notable species of conservation concern recorded in and around the wetland is the Endangered Greater Adjutant. Relatively large numbers of these birds are recorded in the area, specifically concentrating at the Boragaon solid waste disposal site on the eastern side of the wetland where they scavenge through the year.

A number of roads passes around the wetland including the National Highway 37, and a railway line passes along the southern and eastern fringe of the Beel (Figure 1), that has potentially lead to encroachment of the wetland with the establishment of warehouses, industries and habitations. This has also led to increase in power line network to meet the energy demands, increase in flow of sewage into the lake, and establishment of a municipal garbage dumping yard in the vicinity. Also, due to the proximity to Guwahati city high number of picnickers especially at weekends visit the wetland, and large gatherings for recreation occur during the holiday season in the winter months causing disturbance to birds. Several actions to mitigate and manage these threats have been proposed however remains to be effectively implemented.

Figure 1. Map of the Deepor Beel Ramsar Site located south of the Brahmaputra River



Note: The boundary of the Deepor Beel Wildlife Sanctuary shown in the map here was provided by the GIS Department of the Assam Forest Department.

Methodology

Mapping and characterization of power lines

For assessing the impacts of power line on birds, a combination of on-ground field surveys (January to May 2021) and lab-based GIS approaches were carried out to achieve the project objectives. Mapping and characterization of the distribution and transmission lines in the area surveyed around Deepor Beel was first carried out. The GPS location of each power pole (pylons) of the transmission line along with information on voltage type (kV), height of the pylon, number of conductor and earth wires, separation distance between conductor wires, and the distance of the lowest conductor wire to ground were recorded. Similarly, in the case of distribution lines, the voltage (kV) type, the height of the pole, cross-arm length, separation distance between phase wires were recorded. These power poles were categorized into different types based on their structural design and further classified in terms of their potential risk of electrocution to birds as very high risk, high risk, medium, low and no risk.

Collision & Electrocution Risk Assessment

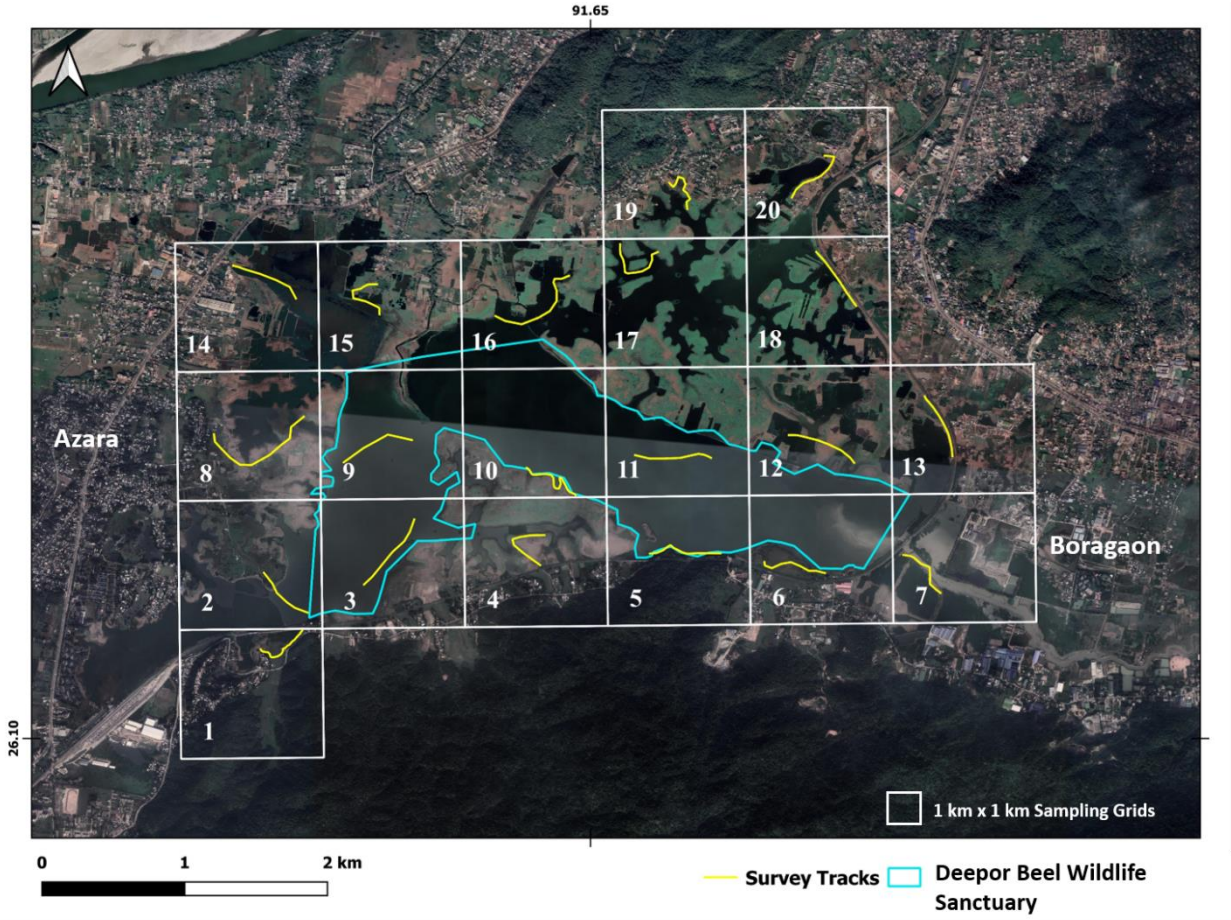
For assessing collision risk that is primarily associated with transmission lines observations of birds crossing different line stretch (Spans) were made from a designated spot or vantage point at each, and during March and April month during the study. Observations were made for a two-hour duration and at each span on different days, and only during the morning hours between 07:00 to 11:00 am when birds are most active. When a bird or flock of birds in flight approached the power line the species and their number were recorded. The flight observation was then characterized as: change in flight height (either gained height to fly above the earth wire, or lowered height to fly below the lowest conductor wire, and or fly through the wires), splitting of flocks while attempting to cross the line, and change of course to either return and reattempt. In those observations of birds crossing the line, information on whether the crossing was made above or below the earth wire, and whether it was high risk crossing where birds crossed either between the earth wire and conductor wire, or between conductor wires was recorded. Lastly, dangerous interactions such as flaring, near-collision and collision of birds while crossing the line were recorded. Where accessible we undertook regular walks below the transmission line to locate bird carcasses that may have resulted from a collision. The information collected on the above were summarized to identify the transmission line span posing high collision risk, and the select bird species that faced maximum risk.

To assess the electrocution risks posed by distribution lines we carried out vehicular and foot surveys of the lines to document mortality of birds. The vehicular surveys were made on a two-wheeler driven at a speed of 10-20 km/h with frequent stops at power poles to search for bird carcasses or remains. The distribution lines in the area were segregated into northern, eastern, southern and western section, and dedicated surveys of each were made through out the study period. The cross arms of the distribution line poles were also scanned for remains of feathers that may have resulted from an electrocution. In the case of an electrocution mortality information on the bird species, distribution pole type including the line characteristics were recorded.

Distribution mapping of bird species associated with Deepor Beel

In order to document the spatial distribution of bird species associated with the Beel, a grid-based systematic sampling approach was adopted. For this, the wetland was divided into 20 grids (1 x 1 km) and within each a sampling trail approximately 500 m in length was identified and surveyed by foot (Figure 2). Additionally, few grids being primarily open water expanse were surveyed from a non-motorized boat. The grids were surveyed once every fortnight and in all nine visits were made in each grid between January to first week of May. This period coincided with the wintering and return migration of a number of waterbirds and few water associate species. The grid survey was conducted in the morning between 08:00 to 10:00 am and during the survey information on the bird species along with their abundance were recorded. From the survey data heatmaps of species richness, overall average abundance, and an average Simpson's Evenness Index for each grid was generated to depict areas of high importance for birds within the Beel. The heatmaps were generated in QGIS (Version 3.4.9-Madeira) and were then overlaid with the power lines mapped in the area to assess the collision and electrocution risks posed to birds.

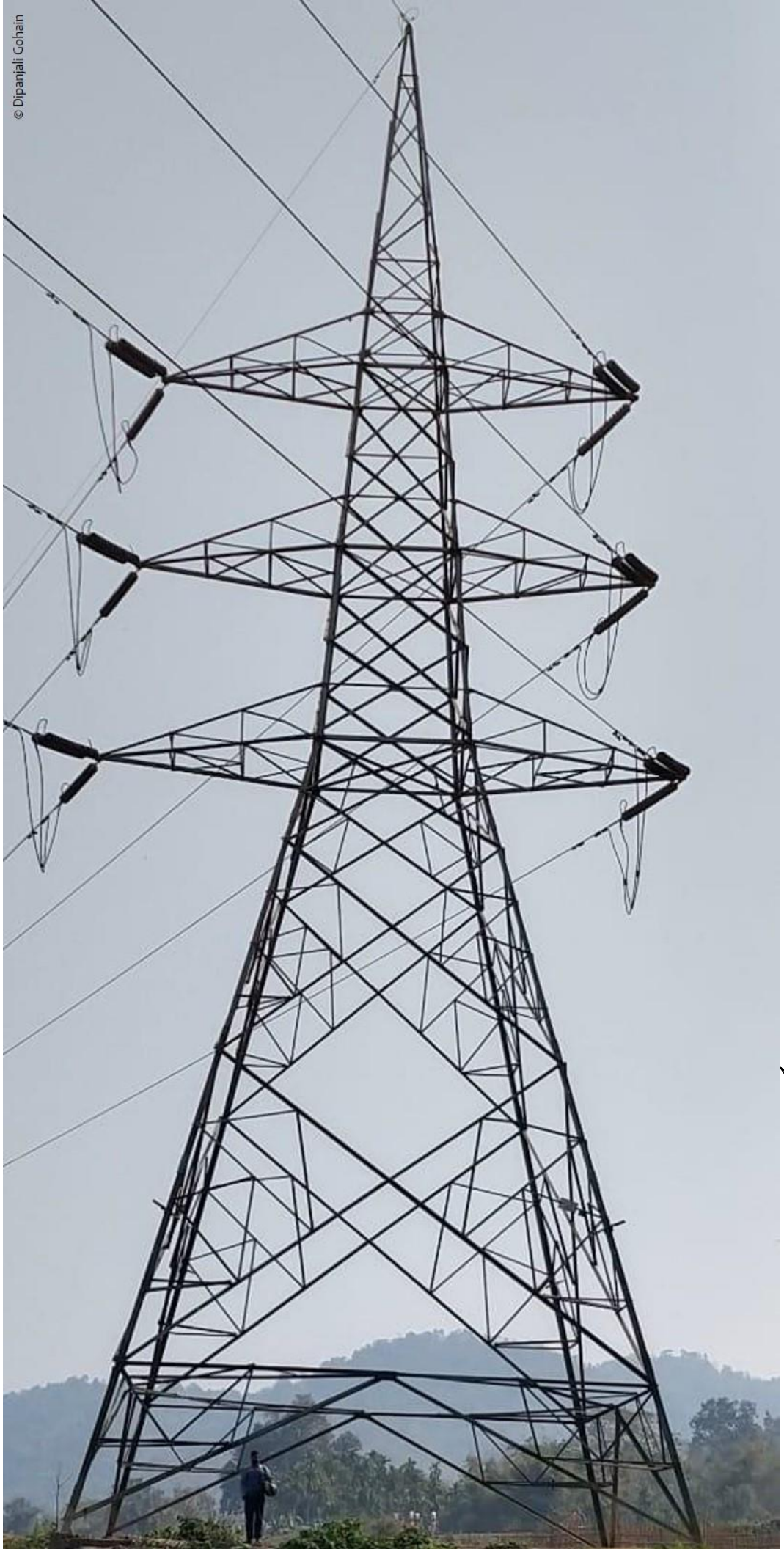
Figure 2. Map of the Deepor Beel wetland showing the 20 grids that were sampled from the survey trails (yellow tracks) to document and map select waterbirds and wetland associated species.



Findings of the study

Power lines of the Deepor Beel Wetland

A single high voltage power line of 220 kV capacity of the Assam Electricity Grid Corporation Limited (AEGCL) connecting the Kukurmara and Sarusajai substations was the only transmission line observed in the vicinity of the Deepor Beel wetland. Part of this line spanning a length of approx. 11 km falls on the southern fringe of the wetland and along the Rani-Garbhanga Reserve Forest (Figure 1). On the eastern side of the area surveyed approx. 4 km of this line stretch passes through the Pamohi village. It is also here where the Kalamani river flows and opens into the beel, and the habitat is predominantly agriculture with few industrial setups, and the Boragaon disposal site (garbage dump) is located here. The 11 km transmission line section consists a total of 36 pylons (steel lattice) each measuring approx. 25 meters in height and carries six conductor wires (3 on each side), and with a single earth wire. The distance between two pylons ranged from the shortest being 130 meter to the longest being 420 meter. The longest is also the line span that cuts across a water stretch in the wetland and is relatively saggy making it closer to the water surface. And, during high water level in the wetland this distance is further reduced and falls in the flight path of birds using the area posing collision risk.

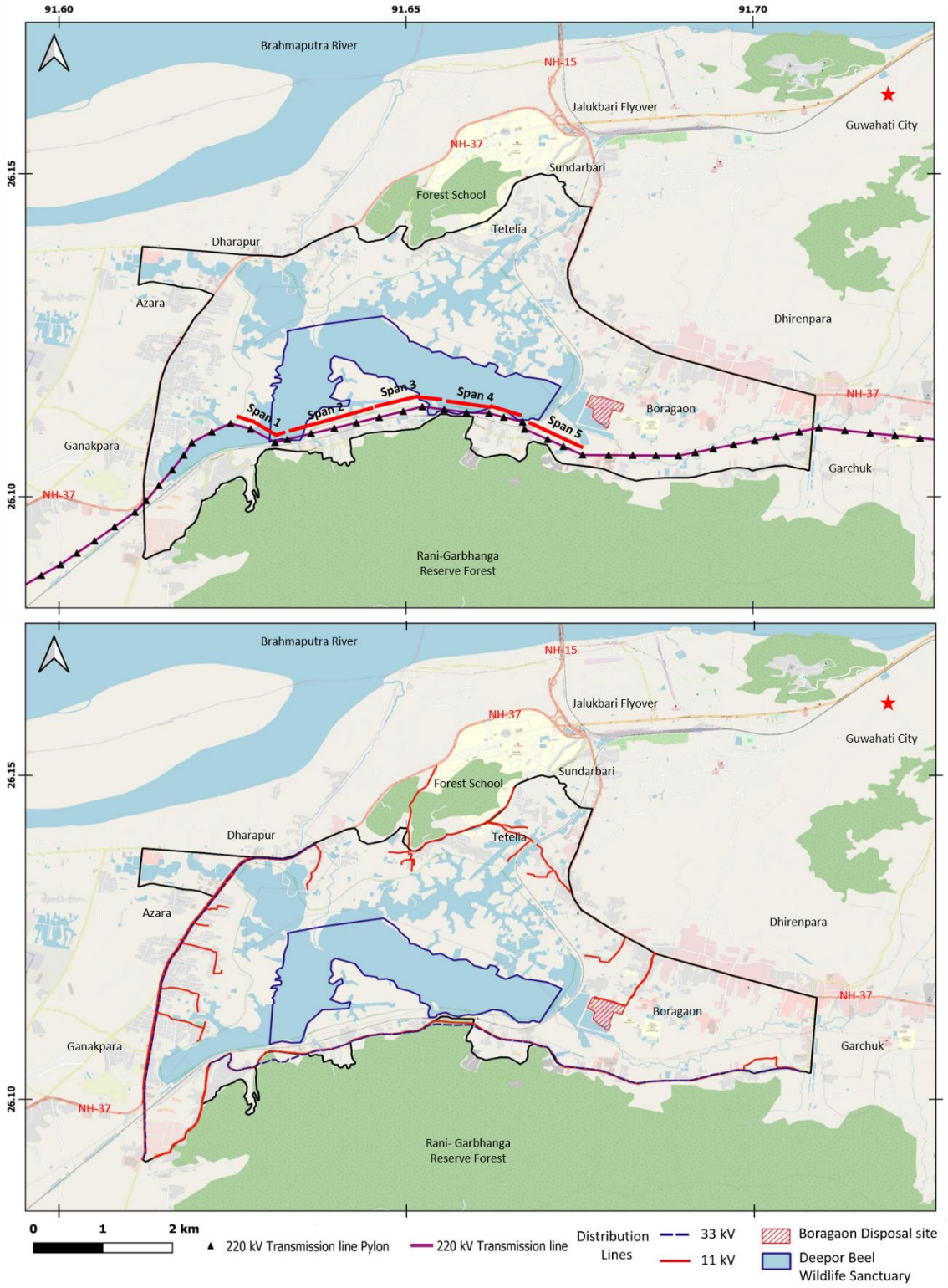


The 220 kV transmission line in the area has three phase wires on either side of the pylon and was well separated and as a result do not pose electrocution risk, while pose the risk of collision to birds in flight

For assessing collision risk to birds, the transmission line stretch from near to Azara railway station to the point near Boragaon disposal site spanning a length of 5.15 km was selected. This line stretch had 19 pylons and was demarcated into five spans with varying length (Figure 3). The line span 1 (900 m) and 3 (970 m) had three line sections, while span 2 (1380 m), span 4 (1160 m) and Span 5 (1070 m) had four line sections. The longest line span section was 420 m and this was over water and is part of span 1. The transmission line stretch beyond these spans were not included for the collision risk observations since during preliminary surveys very low bird activity was observed there, which was likely a result of presence of habitations and construction works.

The distribution lines as expected were relatively more in number and in all 30 lines spanning a total length of 41.19 km (11 kV) and 14.01 km (33 kV) in and around Deepor Beel was mapped and surveyed (Figure 3; Table 1). The distribution lines were primarily all along the roadside except for one 33 kV line (8.86 km) located along the southern fringe of the Beel that cut through forested tracts of the Rani-Garbhanga Reserve Forest in certain parts. The distribution lines in the area were predominantly with three phase wires held atop a single utility pole that was mostly metal, and the poles were on average 10 m in height. At line junctions, the number of utility poles were variable and ranged from 2 to 4. The three phase wires were held on pin insulators atop a metal cross arm, and in few cases from suspended insulators. On few poles, additional phase wires were observed below the main cross arm.

Figure 3. A map of the Deepor Beel Ramsar Site showing the existing power line network in the area that includes one 220 kV transmission line located along the southern boundary and a network of 30 distribution lines of both 11 kV and 33 kV.



The line characteristics in terms of the cross arm length and pole structure were highly variable, and 17 and 23 different types were recorded in the area for the 11 kV and 33 kV respectively (Annexure 1). In cases where there were only two-phase wires the cross arm length was 50 cm, while with three phase wires the length ranged from 100 to 150 cm. The distance between conducting surfaces on these lines was on average 50 cm, and this poses potential electrocution risk to birds in the area. Also, at line junctions the jumper wires connecting the phase wires were not insulated, and are held invariably above the cross arm posing yet again significant electrocution risk.

Table 1. Details of the 11 kV and 33 kV distribution lines surveyed in and around Deepor Beel for this study

Region	Capacity of line (kV)	No. of Lines	Length (km)	No. of Poles	Pole Types
Northern	11	10	6.2	198	10
Eastern	11	5	4.7	184	13
Southern	11	3	14.9	310	12
	33	1	9.5	192	22
Western	11	10	16.7	308	17
	33	1	6.5	141	8
Total	**11**	**28**	**42.5**	**1000**	**17**
	33	**2**	**16.0**	**333**	**23**

Diversity and distribution mapping of birds species associated with Deepor Beel

A total of 120 species of birds were recorded in and around the Deepor Beel during the study off which 80 are resident, 37 are winter migrants and 3 are summer visitors (Annexure 1). Of the 120, 67 species based on their morphology, behavior and habitat use were identified to be those likely impacted by power lines, and included those that are prone to collision risk (40 species), electrocution risk (21 species), and to both risks (6 species). Eight of these species recorded are globally threatened and included the Falcated Duck *Mareca falcata*, Common Pochard *Aythya ferina,* Ferruginous Duck *Aythya nyroca,* Greater Adjutant, Lesser Adjutant *Leptoptilos javanicus,* Oriental Darter *Anhinga melanogaster,* Northern Lapwing *Vanellus vanellus* and Slender-billed Vulture (Table 2). The Baer's Pochard a Critically Endangered species that has been previously reported at the Beel was not recorded during this study. It is possible that this duck may have gone unnoticed given its rarity. One other Critically Endangered species and reported from the Beel previously the White-rumped Vulture was also not recorded during this study. The Lesser Whistling Duck *Dendrocygna javanica* and Fulvous Whistling Duck *Dendrocygna bicolor* both resident species were commonly recorded across the Beel and the former was the most abundant duck species in the area.

Species that faced risk of collision were further observed to fall under two groups: Waterbirds (23 species) that included the Ducks, Geese, Coot, Gull, Tern, Cormorant; and Water Associate species (23 species) that included the Storks, Herons, Ibis, Egrets, Lapwings, Jacana. The diversity and distribution of these birds were therefore examined separately. Based only on the number of species recorded in a grid the Dharapur area in the northern part of the Beel (Grid # 15) had the highest of 35 species of both waterbirds (17 species) and water associates (18 species). This grid being a mosaic of shallow open water and marsh habitat resulted in the high species richness of the two species groups. This grid also had the highest overall average abundance of water associates and in the case of waterbirds it was second to the eastern parts (Grid #12) that had the highest. The Pat Gaon area (Grid # 1) with only five species had the lowest diversity, and only water associates were recorded there. This is because only a small part of this grid sampled is wetland, and the rest is habitations and forested tracts.

Table 2. List of select bird species recorded in Deepor Beel that are prone to power line related collision risk (40 species both waterbirds and water associates), electrocution risk (21 species) and to both (6 species).

S. No	English Name	Scientific Name	Risk	Group*	IUCN Status
1	Fulvous Whistling Duck	*Dendrocygna bicolor*	Collision	W	LC
2	Lesser Whistling Duck	*Dendrocygna javanica*	Collision	W	LC
3	Bar-headed Goose	*Anser indicus*	Collision	W	LC
4	Greylag Goose	*Anser anser*	Collision	W	LC
5	Ruddy Shelduck	*Tadorna ferruginea*	Collision	W	LC
6	Cotton Pygmy Goose	*Nettapus coromandelianus*	Collision	W	LC
7	Garganey	*Spatula querquedula*	Collision	W	LC
8	Northern Shoveler	*Spatula clypeata*	Collision	W	LC
9	Gadwall	*Mareca strepera*	Collision	W	LC
10	Falcated Duck	*Mareca falcata*	Collision	W	NT
11	Eurasian Wigeon	*Mareca penelope*	Collision	W	LC
12	Indian Spot-billed Duck	*Anas poecilorhyncha*	Collision	W	LC
13	Mallard	*Anas platyrhynchos*	Collision	W	LC
14	Northern Pintail	*Anas acuta*	Collision	W	LC
15	Red-crested Pochard	*Netta rufina*	Collision	W	LC
16	Common Pochard	*Aythya ferina*	Collision	W	VU
17	Ferruginous duck	*Aythya nyroca*	Collision	W	NT
18	Great Crested Grebe	*Podiceps cristatus*	Collision	W	LC
19	Eurasian Coot	*Fulica atra*	Collision	W	LC
20	Brown-headed Gull	*Chroicocephalus brunnicephalus*	Collision	W	LC
21	Whiskered Tern	*Chlidonias hybrida*	Collision	W	LC
22	Oriental Darter	*Anhinga melanogaster*	Collision	W	NT
23	Little Cormorant	*Microcarbo niger*	Collision	W	LC
24	Common Moorhen	*Gallinula chloropus*	Collision	WA	LC
25	Grey-headed Swamphen	*Porphyrio poliocephalus*	Collision	WA	LC
26	Black-winged Stilt	*Himantopus himantopus*	Collision	WA	LC
27	Pied Avocet	*Recurvirostra avosetta*	Collision	WA	LC
28	Northern Lapwing	*Vanellus vanellus*	Collision	WA	NT
29	Grey-headed Lapwing	*Vanellus cinereus*	Collision	WA	LC
30	Red-wattled Lapwing	*Vanellus indicus*	Collision	WA	LC
31	Greater Painted-snipe	*Rostratula benghalensis*	Collision	WA	LC
32	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	Collision	WA	LC
33	Bronze-winged Jacana	*Metopidius indicus*	Collision	WA	LC

S. No	English Name	Scientific Name	Risk	Group*	IUCN Status
34	Asian Openbill	*Anastomus oscitans*	Collision	WA	LC
35	Cinnamon Bittern	*Ixobrychus cinnamomeus*	Collision	WA	LC
36	Great Egret	*Ardea alba*	Collision	WA	LC
37	Intermediate Egret	*Ardea intermedia*	Collision	WA	LC
38	Little Egret	*Egretta garzetta*	Collision	WA	LC
39	Black-crowned Night Heron	*Nycticorax nycticorax*	Collision	WA	LC
40	Glossy Ibis	*Plegadis falcinellus*	Collision	WA	LC
41	Lesser Adjutant	*Leptoptilos javanicus*	Both	WA	VU
42	Greater Adjutant	*Leptoptilos dubius*	Both	WA	EN
43	Grey Heron	*Ardea cinerea*	Both	WA	LC
44	Purple Heron	*Ardea purpurea*	Both	WA	LC
45	Cattle Egret	*Bubulcus ibis*	Both	WA	LC
46	Indian Pond Heron	*Ardeola grayii*	Both	WA	LC
47	Eurasian Collared Dove	*Streptopelia decaocto*	Electrocution	-	LC
48	Spotted Dove	*Streptopelia chinensis*	Electrocution	-	LC
49	Yellow-footed Green Pigeon	*Treron phoenicopterus*	Electrocution	-	LC
50	Asian Koel	*Eudynamys scolopaceus*	Electrocution	-	LC
51	Osprey	*Pandion haliaetus*	Electrocution	-	LC
52	Oriental Honey Buzzard	*Pernis ptilorhynchus*	Electrocution	-	LC
53	Slender-billed Vulture	*Gyps tenuirostris*	Electrocution	-	CR
54	Crested Serpent Eagle	*Spilornis cheela*	Electrocution	-	LC
55	Pied Harrier	*Circus melanoleucos*	Electrocution	-	LC
56	Shikra	*Accipiter badius*	Electrocution	-	LC
57	Black Kite	*Milvus migrans*	Electrocution	-	LC
58	Spotted Owlet	*Athene brama*	Electrocution	-	LC
59	Short-eared Owl	*Asio flammeus*	Electrocution	-	LC
60	Indochinese Roller	*Coracias affinis*	Electrocution	-	LC
61	Peregrine Falcon	*Falco peregrinus*	Electrocution	-	LC
62	Rufous Treepie	*Dendrocitta vagabunda*	Electrocution	-	LC
63	House Crow	*Corvus splendens*	Electrocution	-	LC
64	Large-billed Crow	*Corvus macrorhynchos*	Electrocution	-	LC
65	Asian Pied Starling	*Gracupica contra*	Electrocution	-	LC
66	Common Myna	*Acridotheres tristis*	Electrocution	-	LC
67	Jungle Myna	*Acridotheres fuscus*	Electrocution	-	LC

***** W - Waterbirds, WA - Water Associates

The eastern parts of the Beel, the Grid # 11, 12, 13 together had the maximum number of waterbirds with 18 of 22 species. Most of the waterbird encountered here are the migratory ducks and geese (13 species). The Beel here was primarily open water and is bounded by the embankment of a railway line resulting in the area being relatively deeper (on average one meter). It is also here where the River Kalamani that is polluted opens into the Beel and it appears that a high nutrient load may have resulted in higher availability of food to the birds, influencing their presence and abundance. The maximum number of water associate species on the other hand were found in the western parts of the Beel, the Grid # 9 & 15 together had 19 of 23 species. Similarly, the eastern parts of the Beel, the Grid # 7 & 13 together had a high number of these species, with 17 of 23 recorded there.

The Endangered Greater Adjutant and the Vulnerable Lesser Adjutant storks were seen in 13 and 14 of the 20 grids respectively, and were regularly seen in Grid # 7 & 13 specifically. The Boragaon disposal site falling in the Grid # 7 is where the Adjutant storks congregated in large

numbers to forage on the garbage. On one sampling session, 40 and 75 Greater Adjutants were recorded in the Gird # 7 & 13 respectively. Sighting records of over 500 Greater Adjutant storks at one time have been reported at this disposal site (Don Roberson, www.ebird.org/india). Elsewhere across the Beel, the Lesser Adjutant was mostly observed in pairs or solitary, while the Greater Adjutant were seen in small flocks of three to nine individuals and in large flocks as mentioned above. On the whole, Lesser Adjutant were observed to be relatively less common in Deepor Beel than Greater Adjutant storks.

The six other threatened species recorded during the study: the Vulnerable Common Pochard was recorded in 8 of the 20 grids and a highest of 100 individuals was seen in Grid # 19; the Near-Threatened Ferruginous Duck occurred in 13 grids and a highest of 88 individuals was recorded in Grid # 13; the Near-Threatened Oriental Darter was recorded in 8 grids and a highest of 25 individuals was seen in Grid # 11 & 15; and lastly the Near-Threatened Northern Lapwing was seen in four grids and a highest of 15 individuals were recorded in Grid # 4 & 11. The Near-Threatened Falcated Duck, a lone male individual was sighted once in the company of other ducks at Grid # 19. Similarly, a Slender-billed Vulture in flight was sighted only once beyond the Azara railway yard during the study.

An average Simpson's Evenness Index (SEI) of the grids sampled showed waterbirds and water associate species together with their populations to be variable, further signifying certain areas across the Beel to be more important than others (Figure 4 & 5). The interquartile range in the case of waterbirds was widest in the Grid # 4,5 & 8 as on many of the sampling sessions either only few or no birds were recorded there. In Grid # 4 & 5 relatively high human disturbance due to the presence of the Azara-Garchuk road and habitations, along with tourism activity likely influenced waterbirds there. In Grid # 8 much of the area is dry land with shrub cover and the rest was covered with water hyacinth, not a suitable habitat of waterbirds. Similarly, in the case of water associates, Grid # 8, 17 & 19 with 8, 12 & 14 species respectively had wide inter-quartile range. Many of the species recorded there were only seen on few occasions and in relatively low numbers. The Grid # 8 again appeared unsuitable for these birds and the few species that occurred there were only recorded sporadically. In Grid # 19 and 17 fishing activity by local people appears to have influenced water associate species presence.

From the above, the waterbirds in the area appeared to potentially face a lesser risk of collision with the existing transmission line located along the southern fringe of the Beel as the areas they primarily occurred were quite distant, on an average 2 km away. The water associates on the other hand particularly the threatened Greater and Lesser Adjutant were recorded across the Beel and as a result likely face a higher risk of collision or electrocution due to power lines. Around the Boragaon disposal site particularly, the two species congregated in very large numbers and the presence of two 11 kV distribution lines in the immediate vicinity likely pose serious risk of electrocution to the birds.

Figure 4. The species richness, overall average abundance of both waterbirds and water associate species across the Deepor Beel wetland along with the Simpson's Evenness Index were found to be markedly different between and among the two species groups indicating differences in their use of the area.

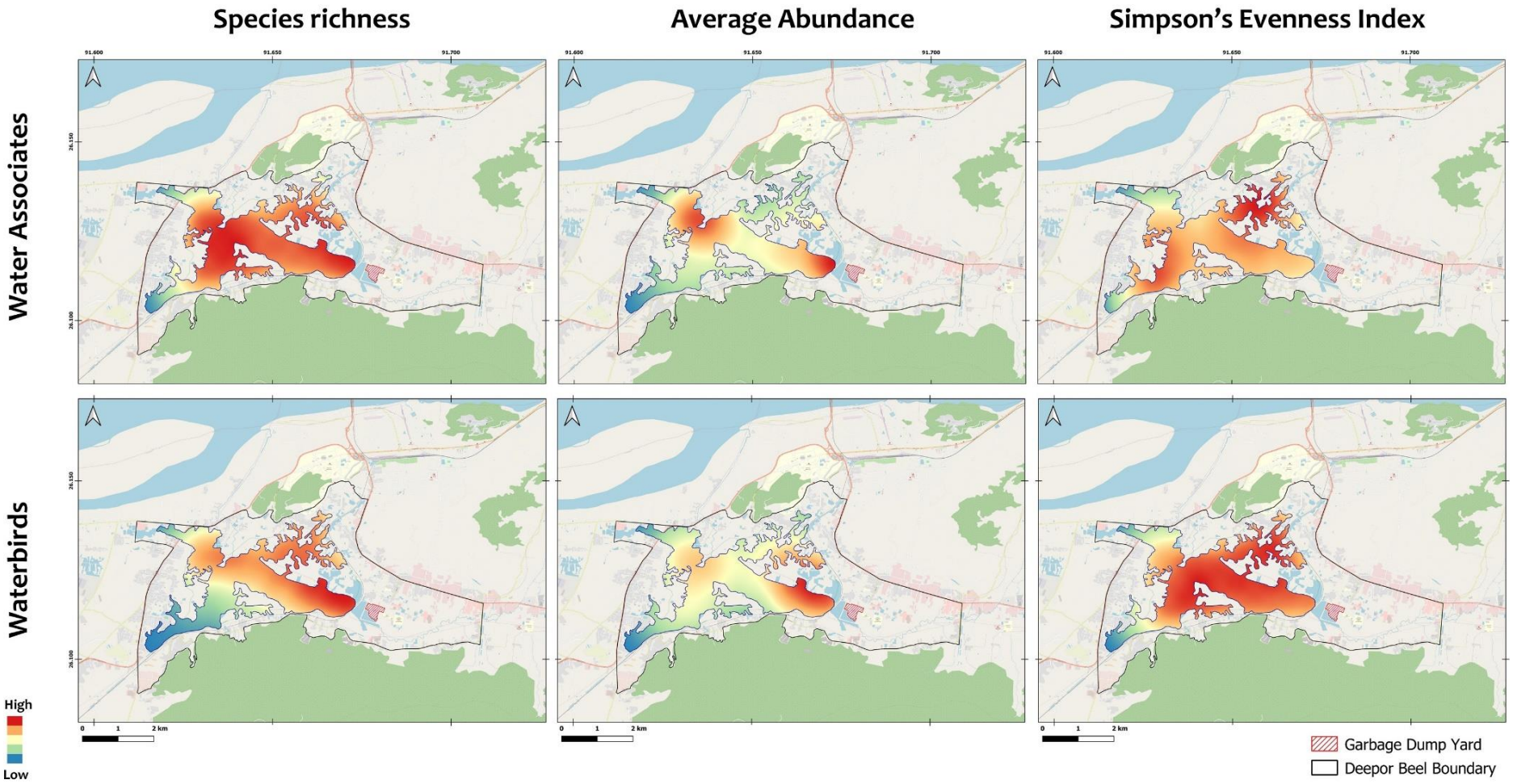
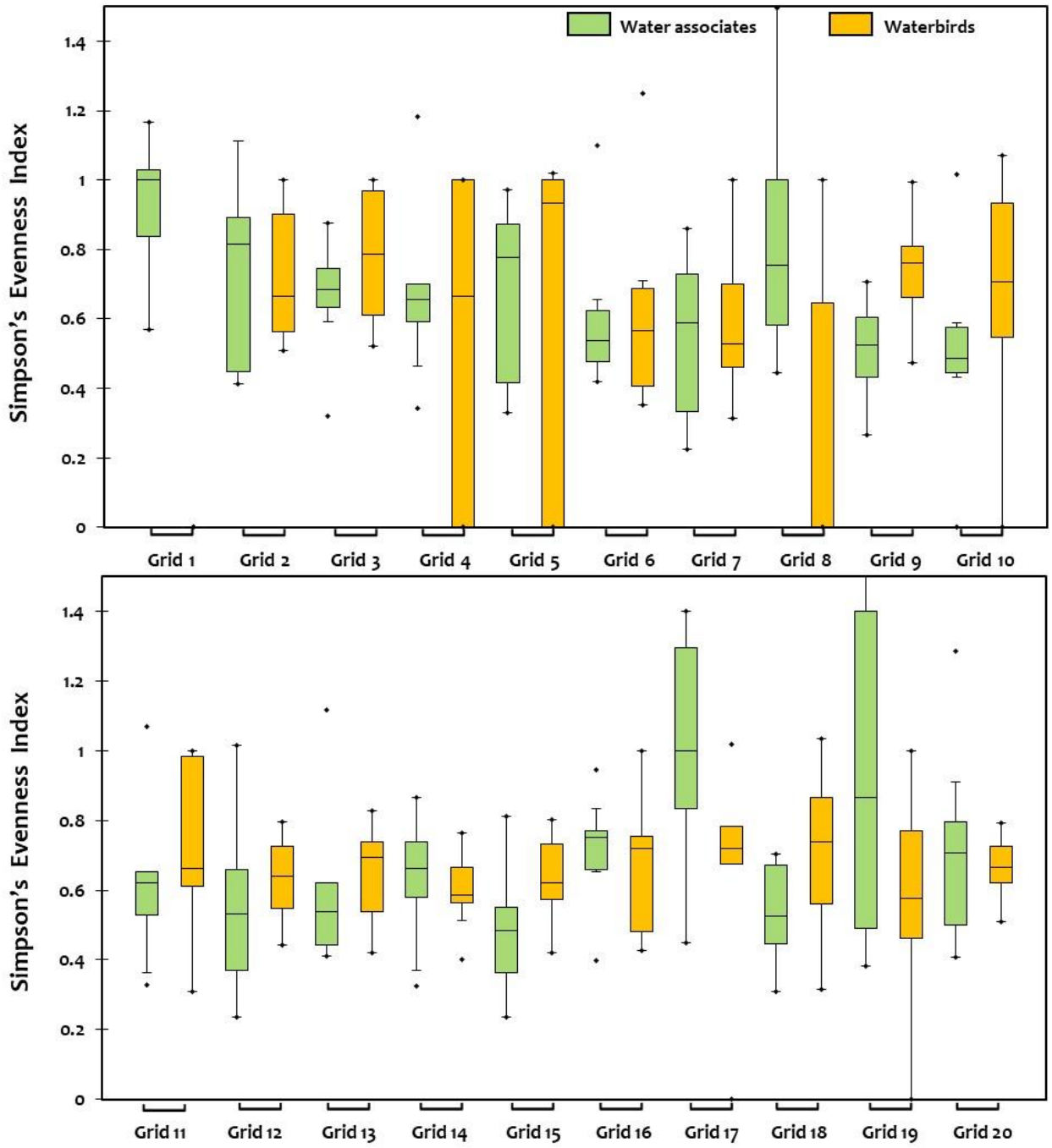


Figure 5. Box plots showing the Simpson's Evenness Index of waterbirds and water associates across the 20 grids surveyed during the study period. Diversity of waterbirds was found to be fluctuating across the grids whereas water associated birds are evenly distributed across the whole area.



Transmission lines and collision risk

A total of 60 hours were spent observing birds crossing the five transmission line spans during the study. This involved 12 hours of observations across different days in each line span, and during this 232 crossings of individual birds/bird flocks totaling 833 individuals of 20 species prone to collisions with power lines were recorded (Table 3). Apart from this, 106 other observations of line crossings by birds (258 individuals) were recorded and these were of the commonly occurring House crow and Black Kite that face no or low risk of collision with power lines, and their observations were not included in the analysis here.

The 20 species recorded crossing the line spans included only four waterbirds, while the rest were water associates. This was expected as during the distribution surveys most waterbirds including the migratory ducks that occurred in large flocks primarily used the Beel well away from the transmission line. It is to be highlighted here that most of these birds were not observed flying towards the southern fringe of the wetland and instead flew out in the direction of the river Brahmaputra to the north. Further, as the southern side of the wetland is bounded by the hill section of the Rani-Garbhanga Reserve Forest that extends into Meghalaya, and this being not a suitable habitat for waterbirds is likely the reason for few observations of these birds crossing the transmission line.

Three of the 20 species: Cattle Egret with the highest of 61 sightings, Lesser Whistling Duck with 39 sightings and Indian Pond Heron with 34 sightings together contributed 58% of the observations of bird flocks or individuals crossing the transmission line (Table 3). The Lesser Whistling Duck being the most commonly seen duck species in the area and occurring in small to large flocks crossed the line spans the most, with 438 individuals recorded crossing. Across the line spans, the span 1 had the highest number of observations (n = 88), and also the highest of 14 species out of 20 crossing the line. This is because this line span passes over a water expanse cutting across the Beel and birds were observed using the area on either side.

Table 3. The list of bird species prone to collision with power lines observed crossing the five different spans of the 220 kV transmission line at Deepor Beel during the study. The numbers given here refer to the total line crossing observations or sightings and those given in parenthesis refer to total individual birds observed.

S. No	Species	Transmission Line Span					All
		1	2	3	4	5	
1	Cattle Egret	9 (13)	12 (15)	11 (20)	18 (27)	11 (14)	61 (89)
2	Lesser Whistling Duck	36 (425)	-	-	3 (13)	-	39 (438)
3	Indian Pond Heron	5 (9)	7 (9)	6 (7)	12 (15)	4 (5)	34 (45)
4	Greater Adjutant	-	-	-	-	16 (24)	16 (24)
5	Asian Openbill	4 (5)	3 (3)	3 (3)	3 (3)	-	13 (14)
6	Fulvous Whistling Duck	11 (88)	-	2 (11)	-	-	13 (99)
7	Little Egret	-	3 (4)	2 (2)	6 (7)	-	11 (13)
8	Red-wattled Lapwing	6 (12)	-	1 (2)	2 (4)	-	9 (18)
9	Intermediate Egret	2 (3)	3 (4)	-	1 (1)	2 (2)	8 (10)
10	Lesser Adjutant	1 (1)	-	-	-	4 (4)	5 (5)
11	Purple Heron	4 (5)	-	1 (1)	-	-	5 (6)
12	Grey-headed Swamphen	4 (6)	-	-	-	-	4 (6)
13	Grey-headed Lapwing	-	-	2 (8)	1 (7)	-	3 (15)
14	Little Cormorant	-	-	1 (2)	2 (2)	-	3 (4)
15	Great Egret	2 (3)	-	-	-	-	2 (3)
16	Whiskered Tern	2 (32)	-	-	-	-	2 (32)
17	Black-crowned Night Heron	-	1 (2)	-	-	-	1 (2)
18	Bronze-winged Jacana	1 (1)	-	-	-	-	1 (1)
19	Cinnamon Bittern	-	1 (1)	-	-	-	1 (1)
20	Glossy Ibis	1 (8)	-	-	-	-	1 (8)
	Total Observations	**88 (611)**	**30 (38)**	**29 (56)**	**48 (79)**	**37 (49)**	**232 (833)**

It was also at this line span where the Lesser Whistling Duck was recorded most frequently crossing, 425 individuals of its total 438 crossed here. The line span 3 & 2 with 29 and 30 observations respectively had the lowest number of bird crossings relatively. And, this is because these two line spans pass close to the hills along the southern fringe of the wetland and also this part of the Beel (Grid # 4 & 5) is relatively less used by birds. At span 5 only five species were observed crossing the line and it was only here that the Greater Adjutant (24 individuals) was recorded. The Lesser Adjutant (4 out of 5 individuals) was again primarily recorded crossing the line here. This is likely as a result of the proximity to the Boragaon disposal site where these two Adjutant storks primarily foraged. The birds that crossed the adjoining line span 4 were also those that are attracted to garbage dumps as was observed from the relatively higher number of Cattle Egret (18 observations of 27 individuals) and Indian Pond Heron (12 observations of 15 individuals) crossing there.

On closer examination of the 232 observations of line crossings by birds, a total of 589 individuals of 130 observations (56%) responded to the line (Table 4). There were 16 species out of the 20 that showed visible response to the line spans. The four species with no response observed were the Grey-headed Swamphen, Whiskered Tern, Bronze-winged Jacana and Cinnamon Bittern. The visible response recorded was either gaining or lowering their flight height, or changed their course, and in many others the birds flying in flocks split up when attempting to cross the line and then few changed course while others flew through the line, or above or below. Here again, as expected line span 1 had the highest observation of 56 involving 466 individual birds showing visible response to the line while crossing. Further, 64% of these responses were of the Lesser Whistling Duck alone (374 individuals).

In those observations (n = 102) where no response could be discerned, it was not visible whether the birds were aware of the presence of the line or that they made a conscious attempt to avoid the line. In 22 of these cases, birds flew just above the earth wire clearing the line safely, while in 80 other cases, the birds crossed the line below the lowest conductor wire. Further, in the latter case, a highest of 31 observations were at span 1 which was over water and it is likely that birds using that area avoided the line obstructing their flight path by flying below it. The Lesser and Fulvous Whistling Duck, Purple Heron,

Grey-headed Swamphen and few others observed crossing here are also those birds that used areas with aquatic vegetation and when in such habitat they generally fly low over the surface moving between patches. The Span 4 with 23 observations of birds crossing from below were primarily Cattle Egret and Indian Pond Heron and these birds foraged in the open meadows around the line and likely moved in and out of the Boragaon disposal site nearby to the forest tract across the line.

Table 4. Sixteen of the 20 bird species that showed a response in the form of change in flight behavior while crossing the five spans of the transmission line during the study. The numbers given here refer to the total line crossing observations or sightings and those given in parenthesis refer to total individual birds observed.

S. No	Species	Transmission Line Span					All
		1	2	3	4	5	
1	Cattle Egret	6 (8)	6 (8)	6 (12)	9 (14)	6 (8)	33 (50)
2	Lesser Whistling Duck	30 (374)			2 (7)		32 (381)
3	Indian Pond Heron	2 (5)	4 (6)	3 (3)	4 (6)	3 (4)	16 (24)
4	Greater Adjutant					3 (3)	3 (3)
5	Asian Openbill	3 (4)	2 (2)	3 (3)	2 (2)		10 (11)
6	Fulvous Whistling Duck	6 (54)		2 (11)			8 (65)
7	Little Egret		2 (3)	2 (2)	2 (3)		6 (8)
8	Red-wattled Lapwing	4 (8)	2 (3)		2 (4)		8 (15)
9	Intermediate Egret	2 (3)			1 (1)	2 (2)	5 (6)
10	Lesser Adjutant					1 (1)	1 (1)
11	Purple Heron	1 (1)		1 (1)			2 (2)
12	Grey-headed Lapwing			1 (4)	1 (7)		2 (11)
13	Little Cormorant				1 (1)		1 (1)
14	Great Egret	1 (1)					1 (1)
15	Black-crowned Night Heron		1 (2)				1 (2)
16	Glossy Ibis	1 (8)					1 (8)
Total Observations		**56 (466)**	**17 (24)**	**18 (36)**	**24 (45)**	**15 (18)**	**130 (589)**

High Risk Crossings

A total of 71 observations of the 130 (55%) were classified as high risk crossings involved birds flying through the transmission line either between the earth wire and conductor wire (27 observations of 86 individuals), or between conductor wires (44 observations of 105 individuals) (Table 5). These high risk crossings by birds were observed in all five spans though most were recorded in Span 1 & 4, with 21 (117 individuals) and 18 (31 individuals) respectively. The maximum number of high risk crossings were made by two common species in the area: Cattle Egret of 27 observations (39 individuals) and Lesser Whistling Duck of 12 observations (86 individuals). The Greater Adjutant was observed making the high risk crossing only on two occasions, while Lesser Adjutant only once and all of these were at the line Span 5. No other threatened species in the area was observed attempting these high-risk crossings. Further, apart from the 71 high risk crossings, 23 other observations wherein flocks splitting up on approaching the line and attempting to cross the line were observed. These involved a total of 264 individual birds with many crossing through the wires, while other crossing above the earth wire or below the conductor wire though these could not be clearly segregated.

No collisions of birds with the line spans were observed during the study, though the Deepor Beel Forest Department personnel informed of two separate cases of collision with the transmission line at Span 3 & 4 of Asian Openbill during April-May 2020. During this study, however dangerous interactions of birds with the lines in the form of near collision (23 observations) and flaring behavior (four observations) were observed. Most of these dangerous interactions were again observed at line Span 1 (20 observations involving 268 individuals), followed by Span 3 & 4 with 4 (13 individuals) and 3 (9 individuals) observations respectively. There were a total of eight species that were involved in these dangerous interactions and they were the Lesser Whistling Duck, Fulvous Whistling Duck, Indian Pond Heron, Asian Openbill, Intermediate Egret, Little Egret, Cattle Egret and Red-wattled Lapwing.

From the above, the Span 1 of the transmission line passing along the southern fringe of the Beel was found to pose relatively higher collision risk to both waterbirds and water

associate species. The other line section that is of concern is Span 5, which section had the highest number of line crossings by the two globally threatened adjutant stork species. The proximity of line Span 5 to the Boragaon disposal site further increases the probability of collision risk of adjutant storks at this span.

Table 5. The change in flight behavior and associated high risk crossings by birds while crossing the 220 kV transmission line spans observed during the study at Deepor Beel.

Crossing Type	Over Earth wire	High Risk Crossings		Below conductor wire	Overall
		Between Earth & conductor wire	Between conductor wire		
Gained/Lowered Height	6 (20)	27 (86)	35 (78) (2 flared, 4 Near collision)	18 (63)	86 (247)
Changed Course	2 (2)	-	9 (27) (4 Near Collision)	10 (49)	21 (78)
Flock Splitting	23 (264) (2 flared, 15 Near Collision)				23 (264)
Total	**8**	**27**	**44**	**28**	**130 (589)**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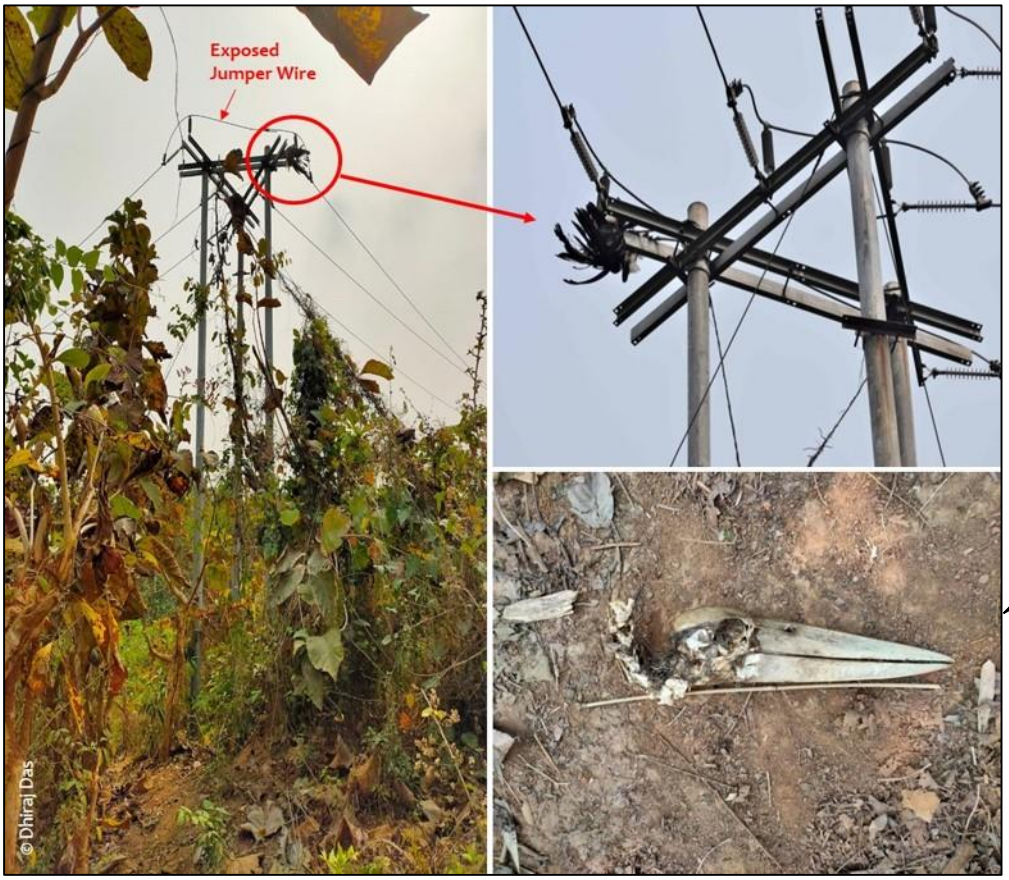
Distribution lines and electrocution risk

To record electrocution related mortality of birds in and around the Beel a total of 350 hours were spent surveying the 11 kV (28 lines) and 33 kV (2 lines) distribution lines, and the lines were surveyed once every 10 days from January through May. Only one case of a Greater Adjutant mortality due to electrocution on a 33 kV line was recorded during the study. This electrocution was on a 3-pole type power pole, which is part of the 33 kV line passing along the southern boundary of the Beel. This specific power pole was part of a span passing through a forested tract of the Rani-Gharbanga Reserve Forest, and was located on a hilly slope, 200 m straight-line distance to the Beel. The structural design of the power pole with 3-meter-long cross arm provided an ideal perching site for large birds like the adjutant storks, and with exposed jumper wires as seen on this pole (See image below) it proved fatal to the bird. The Deepor Beel Forest Department personnel informed of two similar such incidences of electrocution having occurred earlier in the same area.



The remains of a Greater adjutant stork that was observed at the base of the 33 kV power pole that resulted from electrocution

An electrocution risk assessment of the 333 and 1000 power poles of the two 33 kV and twenty-eight 11 kV distribution lines in the area respectively it was found that the poles were highly variable in their structural design and posed differential risks to birds. There were 23 different pole types in 33 kV and 17 types in 11 kV lines (Table 6; Annexure 3). These were assigned to five different risk type classes and was based on the design (number of poles that ranged from 1 to 4, cross arm length, exposed jumper wires present, insulated or not), and what bird species potentially used those poles for perching. The larger or complex pole structures with 2 or more poles at each point and with longer cross arm were classed under Very High and High risk types, and were found to pose serious electrocution risk to birds, specifically to large bodied birds. Together these two types accounted for 34 % and 22% of all the 33 kV and 11 kV poles in the area respectively. On the other hand, the only section that posed no risk to birds was a short stretch of 11 kV line (500 meter) along the perimeter of the Boragaon disposal site. This line stretch with 16 poles and including jumper wires was insulated and so posed no electrocution risk to birds. However, this 11 kV line from one corner of the disposal site and for its remaining length of one km was not insulated and posed electrocution risk.

The fully insulated stretch of a 11 kV power line near Boragaon disposal site.

A two pole type at the same 11 kV line in the vicinity of the disposal site with only partial insulation poses risk of electrocution

Table 6. The details of the different power pole types of the 33 kV and 11 kV lines observed in the area and assigned to the five different risk type classes

S. No	Risk Type	33 kV			11 kV		
		# of poles	# of types	Type ID	# of poles	# of types	Type ID
1	Very High	39	3	3A, 4A, T33	45	3	3A, 4A, T11
2	High	75	6	2A, 2B, 2C, 2D, 2E, 2F	171	6	2A, 2B, 2C, 2D, 2E, 1 G
3	Medium	180	9	1B, 1C, 1F, 1G, 1H, 1J, 1K, 1L, 1M,	31	3	1E, 1F, 1H
4	Low	39	5	1A, 1D, 1E, 1I, 1N	737	5	1A, 1B, 1c, 1D, 1I
5	No Risk*	-	-	-	16		1B, 1C, 2A, 2B
		333	**23**		**1000**	**17**	

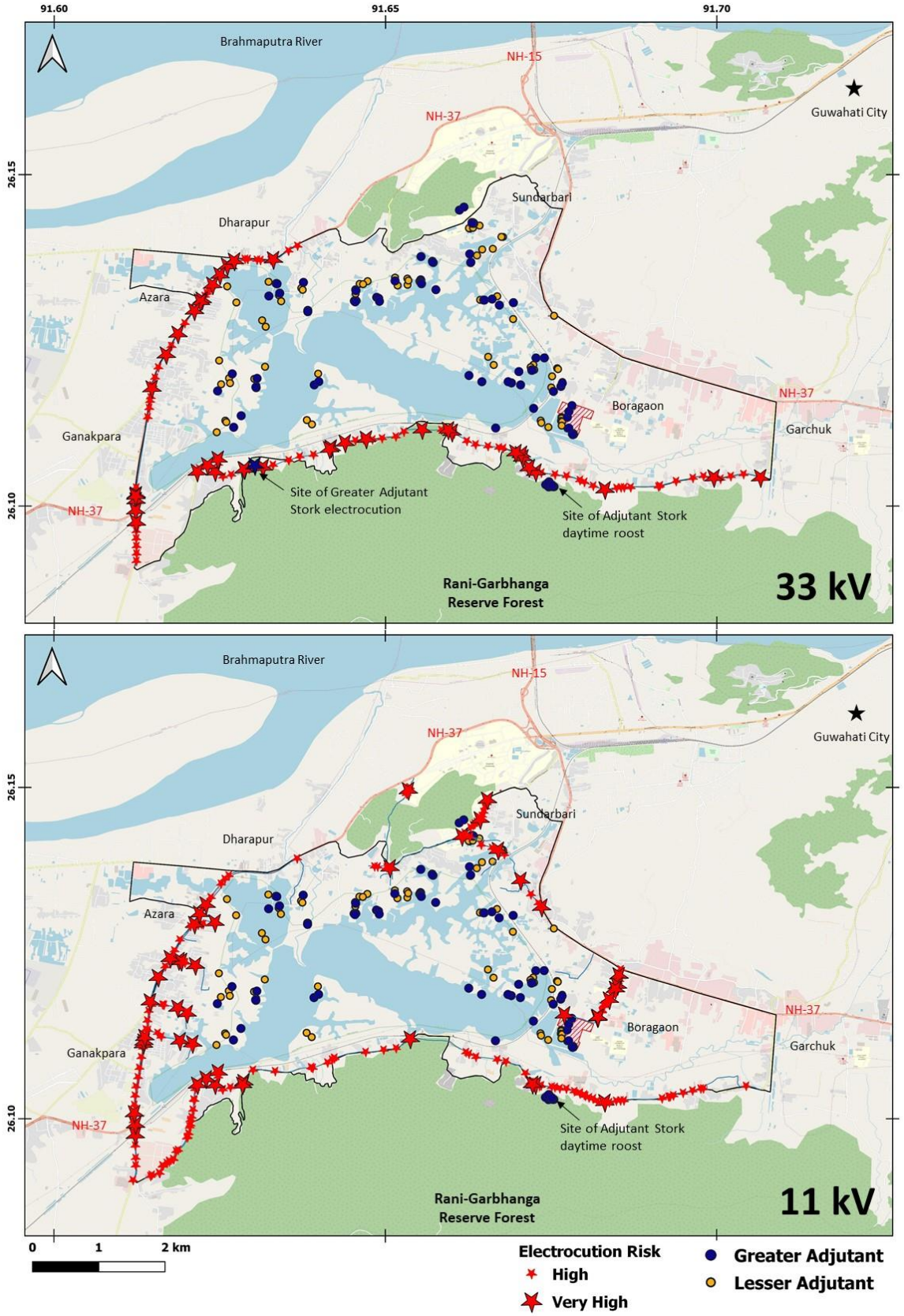
***** 16 poles of four different types seen in one distribution line located adjoining the Boragaon disposal site were categorized as "No Risk" poles since they were insulated and posed no risk of electrocution to birds

Large birds particularly adjutant storks and vultures were found to face higher electrocution risk in the area at power poles that were either with three or two pole design, and those that had transformers. These pole types had relatively longer cross arm (2 to 3 meter), placed horizontally at the top and with multiple cross arms on the same pole providing ideal platform for large birds to perch. While the separation distance between phase wires in these pole types were more and are likely safe for smaller body size birds, this was not the case for larger bodied birds. Added to this, is the presence of exposed jumper wires present on many of these poles increasing the risk of contact between conducting surfaces by the birds simultaneously and resulting in electrocution. These high risk pole types were present on all distribution lines

mapped and across the area. This is of concern as both Greater and Lesser Adjutant stork also occurred across the wetland, though were seen in higher numbers in and around the Boragaon disposal site (Figure 6).

The distribution lines along the southern boundary particularly appears to pose serious risk to the Adjutant storks as the storks appeared to use the forested tracts in the Rani-Garbhanga Reserve Forest as day roost. The storks appeared to shuttle between the forest to the Beel or to the disposal site. With power poles located within the forested tract the Adjutants may readily take to perching atop it, and in the process become prone to electrocution.

Figure 6. The sighting locations of the two Adjutant stork species recorded in and around Deepor Beel during the study along with the locations of 11 kV and 33 kV distribution line power poles that pose Very High/High electrocution risk to the species.



The other relatively large bird species prone to electrocution risk and often observed on power lines in the area was the Black Kite *Milvus migrans*. The kites were recorded in all the 20 grids of this study, though they occurred in large flocks numbering more than 200 individuals in few select grids during January and February, and thereafter their numbers declined. Two such large congregations of kites were observed particularly in Grid # 2 & 6 where they communally roosted on trees at night, and during the day were found resting on transmission line pylons there and on the ground next to it. A highest of 300 kites congregating together was counted once during the grid survey.

The kites were observed to leave the roost tree every morning and shuttle between the transmission line pylons where they roosted during the day and the Boragaon disposal site where they foraged. A large population of kites remained through the day in Grid # 6 as here they appeared to scavenge for food remains left by large number of picnickers visiting the area throughout January on a daily basis. The Black Kites in the area appear to be composed of populations of the migratory subspecies *Milvus migrans lineatus,* which subspecies is a winter visitor to the Indian Subcontinent and likely arrive from Mongolia, China and Russia. The decline in number of kites during the study from early March onwards suggests the populations to may have returned on their spring migration to their breeding grounds.

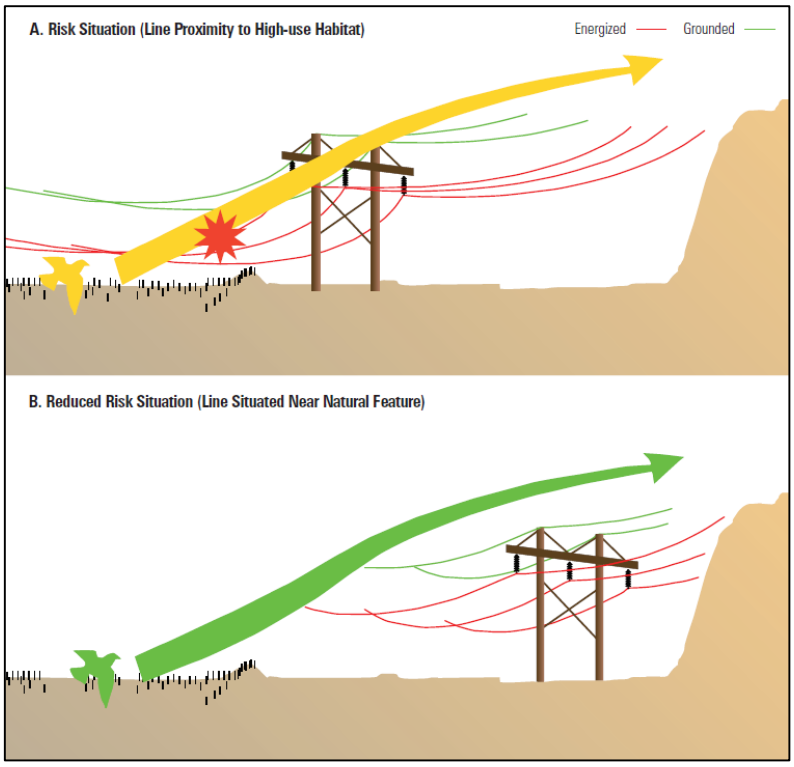
The spatial distribution and use of pylons for day roost by Black Kites during this study was quite predictable, and it appears the kites may not be using the distribution line power poles in the area that often. The kites are however likely to be at risk of electrocution particularly around the disposal site even though no mortalities were recorded during this study. The transmission line pylons where the kites congregated in large numbers posed no electrocution risk as the high voltage phase wires are well separated from conducting surfaces. Further, the kites while in flight were observed to clearly negotiate the transmission line conductor and earth wires, and appeared to escape the risk of collision.

From the above, the structural design of the distribution line power poles dictates electrocution risk of birds in the area, and the pole types affects bird species differently. The power poles located along the southern boundary on the 33 kV and 11 kV line particularly pose serious risk of electrocution to threatened birds like Adjutant storks and Vultures, and to other large bodied birds like Crested Serpent Eagle and Oriental Honey Buzzard associated with the forested habitat there. A number of smaller bird species commonly occurring in the area also readily use distribution line power poles as perch, and a number of these poles in the area pose risk of electrocution. Further, garbage being a major attractant to a number of birds and the presence of power lines nearby increases the probability of electrocution.

Measures to mitigate or minimize power line risks to birds in and around Deepor Beel Ramsar Site

Collision and electrocution risk posed by power lines to birds is influenced by multiple factors that includes structural design of power lines, topography or physical features of the landscape, seasonality, weather conditions and biological traits of bird species. In line with this, the magnitude of the power line risks to birds was observed to vary across the Deepor Beel site, and across time and species. The measures suggested here to mitigate or minimize the impact of power lines on birds follows the guidance document "Eco-friendly measures to mitigate impacts of linear infrastructure on wildlife" (WII, 2016), and others such as APLIC (2006, 2012) and Prinsen et al. (2012). Many of these suggested measures or actions are widely adopted world over.

- **Routing:** The foremost mitigation measure specifically with regard to collision risk to birds is to consider the placement or routing of power lines in the landscape. It is recommended that power lines should be avoided or routed through or near to high bird-use areas as birds will likely encounter the lines more often while landing and taking off increasing the risk of collision. Also, it is recommended that the lines be placed closer to elevated natural features like hill slopes. At Deepor Beel, most parts of the single 220 kV transmission line does adhere to the above in being placed close to the elevated natural feature of the Rani-Gharbanga Reserve Forest. However, few spans of this line in particular the Span # 1 identified in this study passes over a water expanse, which area was observed used by birds. It was also here that the maximum number of dangerous crossings of the line by birds was recorded during the study. To mitigate the potential risk posed by this line span it is suggested that the section of this transmission line starting from Azara station to the line Span # 2 identified in this study (spanning approx. 2.5 km) be rerouted from its current route cutting through the wetland to south of the Azara Railway Yard along the Garchuk road.



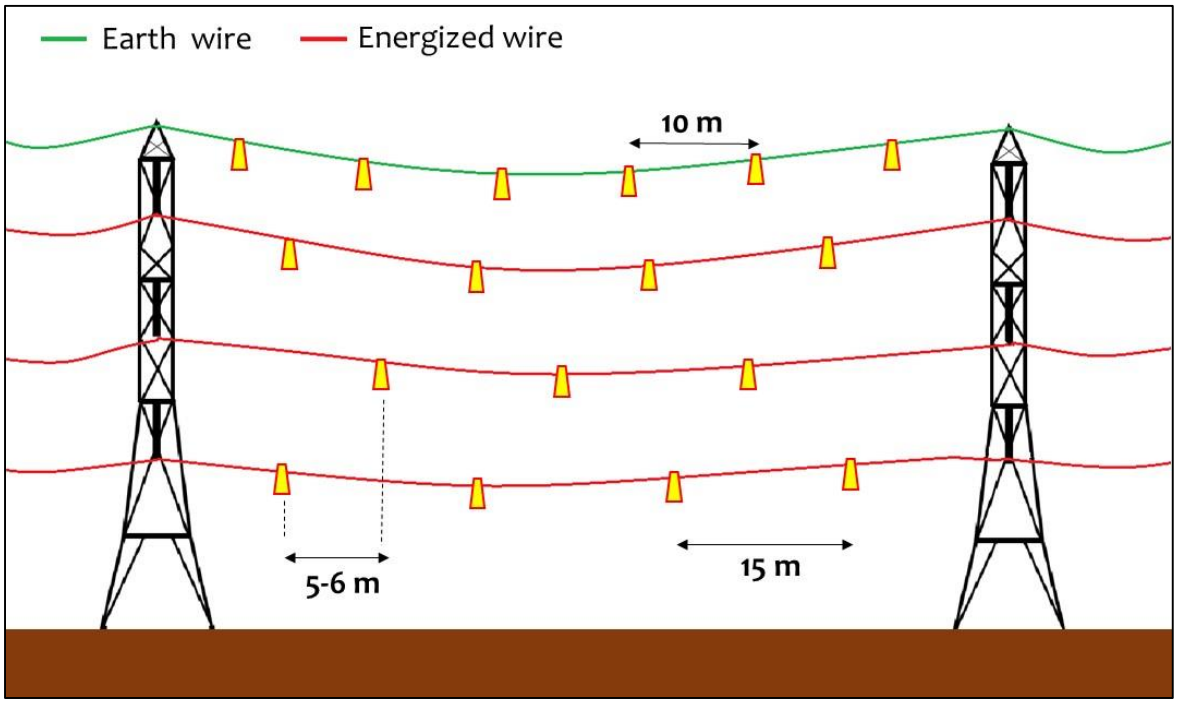
Rerouting the power lines from high bird-use areas to close to elevated natural features to reduce bird collision risk (After Thompson 1978) (Source: APLIC 2012).

- **Undergrounding Power line:** In cases where rerouting is not possible it is recommended to place the problematic stretch of the power line underground. This may be considered for the case at Deepor Beel, though this again comes with its limitations specifically that the line span in question passes over water and placing the line underwater may be challenging.

- **Wire Marking:** In a situation where the power line cannot be rerouted or placed underground then to mitigate the risk of collision a suspended wire marking device or Bird Diverter is used. This is not a permanent mitigation measure as the diverters require to be monitored and maintained periodically. Bird collisions with power lines are reported to frequently occur with the earth wires, and it is this wire that is generally marked with line marking devices. This is particularly the case in western countries and in terrestrial habitats where few species of large birds occur and in low densities. This in unlike the case in tropical regions like in Deepor Beel where there are number of large-bodied species that encounter transmission lines and become vulnerable to both earth and conductor wires. Therefore, it is suggested to mark all wires in the transmission line

spans. The Central Electricity Authority (CEA) in India had produced a technical specification on the use of bird diverters (Anonymous, 2021). It specified the installation of line marking devices on all conductors and earth wire in identified stretches as per requirement to avoid the chances of collision of birds. Based on the above, it is suggested that line marking of the problematic transmission line sections at Deepor Beel specifically, span # 1 and Span # 5 be taken up so as to mitigate collision risks.

- The CEA suggests that one BFD should be installed at every 10 m on the earth wire and again one BFD should be installed at every 15 m on conductor wires in a staggered pattern such that as a whole, the power line will have effectively one diverter at every 5 m to 6 m.



(Schematic diagram showing the positioning of BFDs on earth wires or energized wires of the transmission line)

- **Bird Flight Diverter (BFD):** The BFDs of the suspended type are generally preferred as they readily spin and this increases visibility of the marked line to birds in flight passing through the area. Also, the recommended BFDs should have reflectors on it so as to refract sunlight that can be visible to birds from far. The BFDs should also have

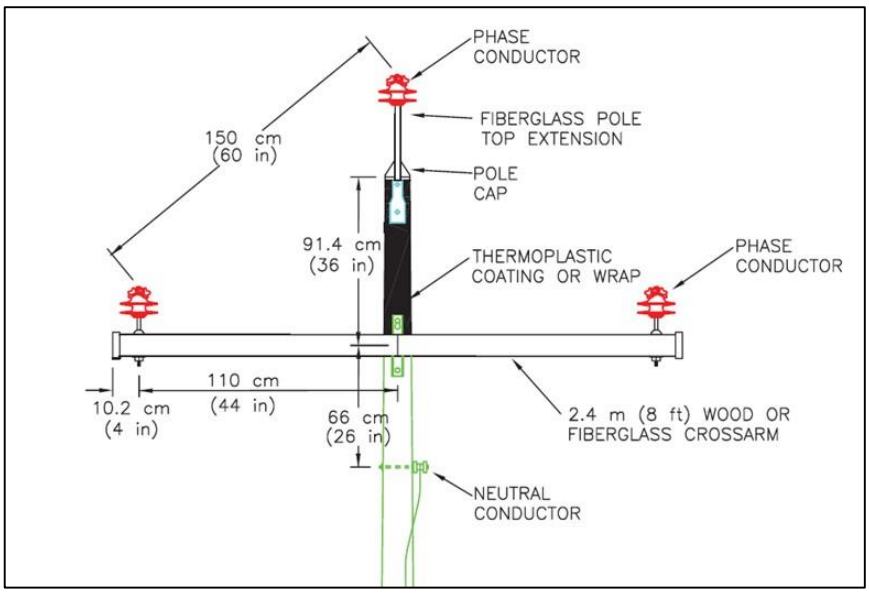
luminescent material so as to glow in the dark and stay lit for long hours after dusk, and also be visible in low light or fog conditions, when birds are most vulnerable. The installation of BFDs on an existing line is simple and fast, and can be installed either by hand or through drones.

The glow in the dark suspended bird flight diverters are widely used around the world to mitigate the risk of bird collision

- In a situation where the transmission line at Deepor Beel is marked with BFDs a study to assess its **efficacy in mitigating collision risk** to birds will require to be taken up. This study should be for a minimum period of one year so as to cover different seasons and involve systematic observations to record behavior of birds in flight while crossing the marked lines.

- Measures suggested to **mitigate electrocution risks** to birds, which is associated with distribution lines is generally again rerouting or undergrounding of problematic sections. This is a long-term measure however, given the innumerable number of distribution lines in and around Deepor Beel and that birds vulnerable to electrocution risk occur across the area rerouting may not be effective, while undergrounding the lines in the area is likely to be an expensive proposition. In situations where these two mitigation measures are not possible retrofitting existing power lines specifically the configuration of the power pole design is recommended to be taken up.

- The **pole design** should primarily consider providing sufficient separation between energized conductors or phases and grounded hardware. The separation distances can be increased by increasing cross-arm length, lowering the position of cross-arm on pole, or installing fibreglass pole extension to elevate the top conductor. Installation of phase wires below the cross arms, using suspension insulators is said to reduce electrocution risk. A 33 kV line section in the area had phase wires installed using suspended insulators (Pole type 1E).



Sufficient separation between phase wires and grounded surfaces on the power pole as shown in the image here is said to minimize electrocution risk

Source: APLIC 2006

- **Insulation:** At Deepor Beel the pole design observed were highly variable making it complex in arriving at a solution. This study however identified power poles that pose serious risk to threatened species such as Adjutant Storks. To prevent electrocutions at these power poles it is suggested that the energized conductor wires, jumper wires and other conducting surfaces be covered by a non-conductor insulation material. Additionally, use fuse cut-out covers, arrester caps and insulation riser termination where necessary. These will require periodic monitoring and maintenance as the insulation material do weather over time and the line may once again pose electrocution risks.

The conductor and jumper wires of this distribution line near Boragaon disposal site were fully insulated. Insulation of high and very high risk poles in the area in a similar way can mitigate the risk of electrocution.

- As a short-term measure discouraging birds from perching on distribution line power poles can be adopted. For this, **perch discouragers** such as brush, spikes and pointed deterrents can be mounted on the cross-arms. However, the installation of perch discouragers may displace birds to other poles where there are no perch discouragers, and therefore should only be used where there are natural perches available in the area. This again will require regular monitoring and maintenance.

- Lastly, **new power lines** that may be proposed to be placed in and around Deepor Beel should avoid placement and routing through high-use areas of birds identified in this study. Further, optimization of the existing transmission line pylon by increasing the voltage capacity and or number of conductors should be considered. This is to avoid placement of any additional transmission line in the area that may increase the collision risk to birds. New distribution lines planned should consider a single pole design standard with sufficient separation between conducting surfaces to avoid electrocution risks.

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Annexure 1

The list of birds recorded in and around Deepor Beel during the study. (R: Resident, WM: Winter Migrant, SM: Summer Migrant, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered)

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
Order: Anseriformes Family: Anatidae				
1	Fulvous Whistling Duck	*Dendrocygna bicolor*	R	LC
2	Lesser Whistling Duck	*Dendrocygna javanica*	R	LC
3	Bar-headed Goose	*Anser indicus*	WM	LC
4	Greylag Goose	*Anser anser*	WM	LC
5	Ruddy Shelduck	*Tadorna ferruginea*	WM	LC
6	Cotton Pygmy Goose	*Nettapus coromandelianus*	WM	LC
7	Garganey	*Spatula querquedula*	WM	LC
8	Northern Shoveler	*Spatula clypeata*	WM	LC
9	Gadwall	*Mareca strepera*	WM	LC
10	Falcated Duck	*Mareca falcata*	WM	NT
11	Eurasian Wigeon	*Mareca penelope*	WM	LC
12	Indian Spot-billed Duck	*Anas poecilorhyncha*	R	LC
13	Mallard	*Anas platyrhynchos*	WM	LC
14	Northern Pintail	*Anas acuta*	WM	LC
15	Red-crested Pochard	*Netta rufina*	WM	LC
16	Common Pochard	*Aythya ferina*	WM	VU
17	Ferruginous Duck	*Aythya nyroca*	WM	NT
Order: Podicipediformes Family: Podicipedidae				
18	Little Grebe	*Tachybaptus ruficollis*	R	LC
19	Great Crested Grebe	*Podiceps cristatus*	WM	LC
Order: Columbiformes Family: Columbidae				
20	Eurasian Collared Dove	*Streptopelia decaocto*	R	LC
21	Spotted Dove	*Streptopelia chinensis*	R	LC
22	Yellow-footed Green Pigeon	*Treron phoenicopterus*	R	LC

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
Order: Cuculiformes Family: Cuculidae				
23	Asian Koel	*Eudynamys scolopaceus*	R	LC
24	Common hawk Cuckoo	*Hierococcyx varius*	R	LC
25	Indian Cuckoo	*Cuculus micropterus*	R	LC
Order: Caprimulgiformes Family: Apodidae				
26	Asian Palm Swift	*Cypsiurus balasiensis*	R	LC
Order: Gruiformes Family: Rallidae				
27	Common Moorhen	*Gallinula chloropus*	R	LC
28	Eurasian Coot	*Fulica atra*	R	LC
29	Grey-headed Swamphen	*Porphyrio porphyrio*	R	LC
30	White-breasted Waterhen	*Amaurornis phoenicurus*	R	LC
Order: Charadriiformes Family: Recurvirostridae				
31	Black-winged Stilt	*Himantopus himantopus*	R	LC
32	Pied Avocet	*Recurvirostra avosetta*	WM	LC
Family: Charadriidae				
33	Northern Lapwing	*Vanellus vanellus*	WM	NT
34	Grey-headed Lapwing	*Vanellus cinereus*	WM	LC
35	Red-wattled Lapwing	*Vanellus indicus*	R	LC
36	Little Ringed Plover	*Charadrius dubius*	R	LC
Family: Rostratulidae				
37	Greater painted-snipe	*Rostratula benghalensis*	R	LC
Family: Jacanidae				
38	Pheasant -tailed Jacana	*Hydrophasianus chirurgus*	R	LC
39	Bronze -winged Jacana	*Metopidius indicus*	R	LC
Family: Scolopacidae				
40	Common Sandpiper	*Actitis hypoleucos*	WM	LC
41	Wood Sandpiper	*Tringa glareola*	WM	LC

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
Family: Glareolidae				
42	Oriental Pratincole	*Glareola maldivarum*	R	LC
Family: Laridae				
43	Brown -headed Gull	*Chroicocephalus brunnicephalus*	WM	LC
44	Whiskered Tern	*Chlidonias hybrida*	SM	LC
Order: Ciconiiformes Family: Ciconiidae				
45	Asian Openbill	*Anastomus oscitans*	R	LC
46	Lesser Adjutant	*Leptoptilos javanicus*	R	VU
47	Greater Adjutant	*Leptoptilos dubius*	R	EN
Order: Suliformes Family: Anhingidae				
48	Oriental Darter	*Anhinga melanogaster*	R	NT
Family: Phalacrocoracidae				
49	Little Cormorant	*Microcarbo niger*	R	LC
Order: Pelecaniformes Family: Threskiornithidae				
50	Glossy Ibis	*Plegadis falcinellus*	WM	LC
Family: Ardeidae				
51	Cinnamon Bittern	*Ixobrychus cinnamomeus*	R	LC
52	Grey Heron	*Ardea cinerea*	R	LC
53	Purple Heron	*Ardea purpurea*	R	LC
54	Great Egret	*Ardea alba*	R	LC
55	Intermediate Egret	*Ardea intermedia*	R	LC
56	Little Egret	*Egretta garzetta*	R	LC
57	Cattle Egret	*Bubulcus ibis*	R	LC
58	Indian Pond Heron	*Ardeola grayii*	R	LC
59	Black-crowned night heron	*Nycticorax nycticorax*	SM	LC
Order: Accipitriformes Family: Pandionidae				
60	Osprey	*Pandion haliaetus*	WM	LC

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
Family: Accipitridae				
61	Oriental Honey Buzzard	*Pernis ptilorhynchus*	R	LC
62	Slender-billed Vulture	*Gyps tenuirostris*	R	CR
63	Pied Harrier	*Circus melanoleucos*	WM	LC
64	Crested Serpent Eagle	*Spilornis cheela*	R	LC
65	Shikra	*Accipiter badius*	R	LC
66	Black Kite	*Milvus migrans*	R	LC
Order: Strigiformes Family: Strigidae				
67	Short-eared owl	*Asio flammeus*	WM	LC
68	Asian Barred Owlet	*Glaucidium cuculoides*	R	LC
69	Spotted Owlet	*Athene brama*	R	LC
Order: Bucerotiformes Family: Upupidae				
70	Eurasian Hoopoe	*Upupa epops*	R	LC
Order: Coraciiformes Family: Alcedinidae				
71	Common Kingfisher	*Alcedo atthis*	R	LC
72	Stork-billed Kingfisher	*Pelargopsis capensis*	R	LC
73	White-throated Kingfisher	*Halcyon smyrnensis*	R	LC
74	Pied Kingfisher	*Ceryle rudis*	R	LC
Family: Meropidae				
75	Green Bee-eater	*Merops orientalis*	R	LC
76	Blue-tailed Bee-eater	*Merops philipiinus*	R	LC
Family: Coraciidae				
77	Indochinese Roller	*Coracias affinis*	R	LC
Order: Piciformes Family: Megalaimidae				
78	Coppersmith barbet	*Psilopogon haemacephalus*	R	LC
79	Blue-throated barbet	*Psilopogon asiaticus*	R	LC
Family: Picidae				
80	Fulvous breasted Woodpecker	*Dendrocopos macei*	R	LC
Order: Falconiformes Family: Falconidae				

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
81	Peregrine Falcon	*Falco peregrinus*	WM	LC

Order: Psittaciformes Family: Psittaculidae				
82	Rose-ringed Parakeet	*Psittacula krameri*	R	LC
Order: Passeriformes Family: Oriolidae				
83	Black-hooded Oriole	*Oriolus xanthornus*	R	LC
Family: Artamidae				
84	Ashy Woodswallow	*Artamus fuscus*	R	LC
Family: Dicruridae				
85	Black Drongo	*Dicrurus macrocercus*	R	LC
Family: Laniidae				
86	Grey- backed Shrike	*Lanius tephronotus*	WM	LC
87	Brown shrike	*Lanius cristatus*	WM	LC
88	Long-tailed Shrike	*Lanius schach*	WM	LC
Family: Corvidae				
89	Rufous Treepie	*Dendrocitta vagabunda*	R	LC
90	House Crow	*Corvus splendens*	R	LC
91	Eastern jungle crow	*Corvus levaillantii*	R	LC
Family: Paridae				
92	Cinereous Tit	*Parus cinereus*	R	LC
Family: Alaudidae				
93	Bengal bush-lark	*Mirafra assamica*	R	LC
Family: Cisticolidae				
94	Common Tailorbird	*Orthotomus sutorius*	R	LC
95	Yellow-bellied prinia	*Prinia flaviventris*	R	LC
Family: Locustellidae				
96	Striated Grassbird	*Megalurus palustris*	R	LC
Family: Hirundinidae				
97	Sand Martin	*Riparia riparia*	WM	LC
98	Barn Swallow	*Hirundo rustica*	WM	LC

S. No.	Common Name	Scientific Name	Resident / Migratory	IUCN Status
Family: Pycnontidae				
99	Red-vented Bulbul	*Pycnonotus cafer*	R	LC
100	Red-whiskered Bulbul	*Pycnonotus jocosus*	R	LC
Family: Leiothrichidae				
101	Jungle Babbler	*Argya striata*	R	LC
Family: Sturnidae				
102	Common Hill Myna	*Gracula religiosa*	R	LC
103	Asian Pied Starling	*Gracupica contra*	R	LC
104	Chestnut- tailed starling	*Sturnia malabarica*	R	LC
105	Common Starling	*Sturnus vulgaris**	WM	LC
106	Common Myna	*Acridotheres tristis*	R	LC
107	Jungle Myna	*Acridotheres fuscus*	R	LC
108	Great Myna	*Acridotheres grandis*	R	LC
Family: Muscicapidae				
109	Oriental Magpie-Robin	*Copsychus saularis*	R	LC
110	Siberian Stonechat	*Saxicola maurus*	WM	LC
Family: Nectariniidae				
111	Purple Sunbird	*Cinnyris asiaticus*	R	LC
Family: Ploceidae				
112	Baya Weaver	*Ploceus philippinus*	R	LC
Family: Estrildidae				
113	Scaly-breasted Munia	*Lonchura punctulata*	R	LC
Family: Passeridae				
114	House sparrow	*Passer domesticus*	R	LC
115	Eurasian Tree Sparrow	*Passer montanus*	R	LC
Family: Motacillidae				
116	Grey Wagtail	*Motacilla cinerea*	WM	LC
117	Citrine Wagtail	*Motacilla citreola*	WM	LC
118	White Wagtail	*Motacilla alba*	WM	LC
119	Paddyfield Pipit	*Anthus rufulus*	R	LC
120	Rosy Pipit	*Anthus roseatus*	WM	LC

*a flock of five Common Starlings was seen on 05.03.2021 in Grid # 15 in the northern part of the Beel and were foraging near a herd of domestic buffaloes grazing there, and is the first sighting of the species for Deepor Beel.

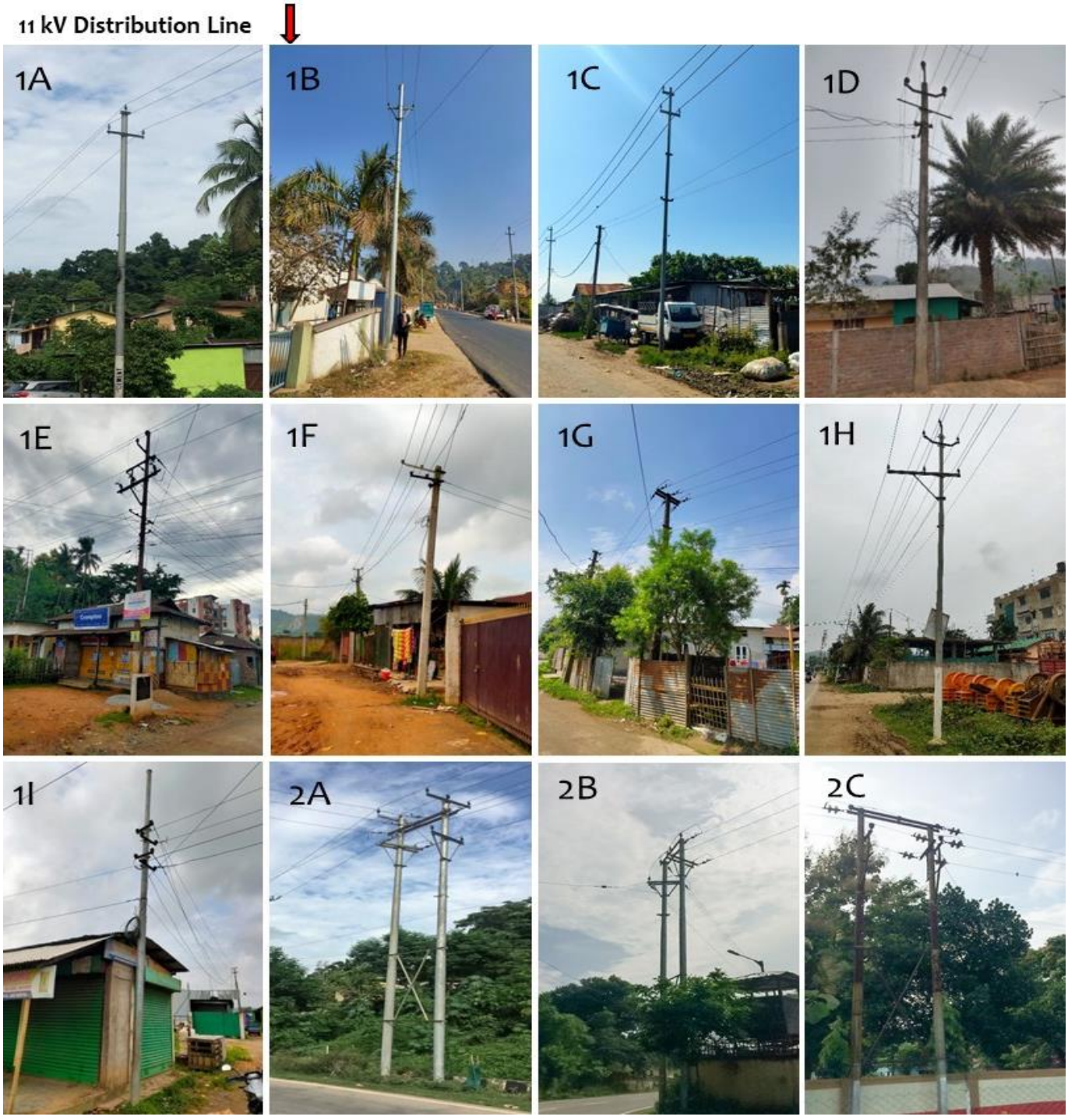
Annexure - 2

The Species richness, Overall average abundance and the Simpson's Evenness Index of waterbirds and water associate species recorded during the study in each of the 20 grids at Deepor Beel

Grid #	Waterbirds			Water Associate species		
	Species Richness	Overall Average Abundance	Simpson's Evenness Index	Species Richness	Overall Average Abundance	Simpson's Evenness Index
1	0	0	0	5	11	0.91
2	2	135	0.72	14	47	1.00
3	2	82	0.78	17	34	0.67
4	6	37	0.56	13	37	0.68
5	4	11	0.61	11	23	0.69
6	12	162	0.60	14	75	0.60
7	13	105	0.58	17	138	0.55
8	4	39	0.26	10	22	0.88
9	4	135	0.74	15	56	0.51
10	7	43	0.65	13	40	0.50
11	14	178	0.70	14	82	0.62
12	14	270	0.62	15	66	0.54
13	11	191	0.65	16	111	0.64
14	11	120	0.60	14	59	0.63
15	17	191	0.63	18	174	0.49
16	11	90	0.67	12	28	0.71
17	9	95	0.66	12	17	1.00
18	6	104	0.70	15	49	0.53
19	13	88	0.59	14	25	1.11
20	12	54	0.66	4	47	0.71

Annexure - 3

Distribution line pole characteristics - The images below depict the structural differences in the poles of 11 kV and 33 kV distribution lines surveyed in and around Deepor Beel. The alpha-numeric codes on the image refers to whether it is single (1), double (2), triple (3) or quadra (4) pole type and the alphabet refers to individual types. In all 17 and 23 different pole types were seen in the 11 kV and 33 kV respectively.



33 kV Distribution Line


1K


1L


1M


1N


2A


2B


2C


2D

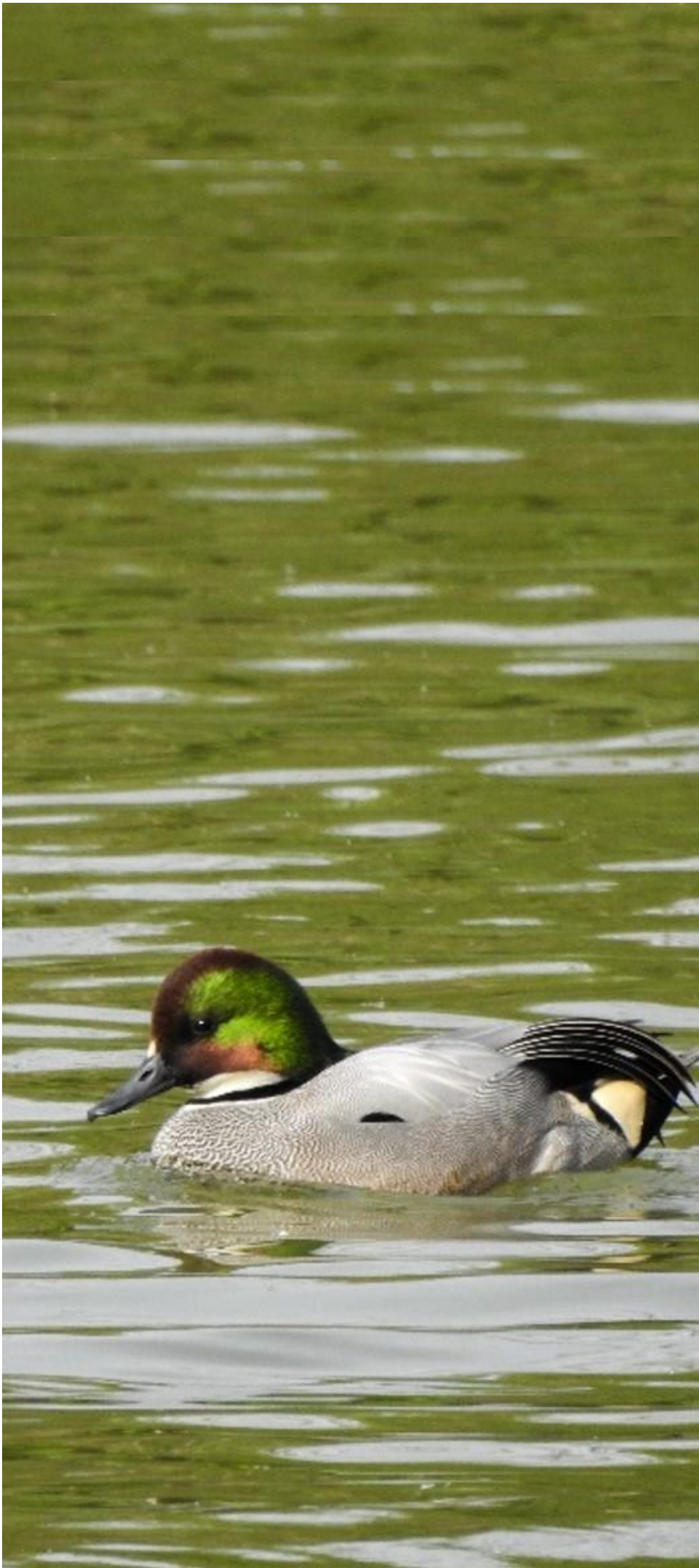

2E


2F


3A


4A


T33



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