Monitoring of wintering geese in the AES Geo Energy Wind Farm "Sveti Nikola" territory and the Kaliakra region in winter 2012/2013

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TERMS OF USE

Contents

Introduction

The report presents results of the ornithological survey and monitoring at Saint Nikola Wind Farm (SNWF) in the period 01 December 2012 to15 March 2013, continuing from similar studies in previous winters before and after construction of SNWF. The primary objective of wintering bird studies at SNWF is to investigate the possible effects of the wind farm on geese populations, notably the Red-breasted Goose *Branta ruficollis* (RBG) due to its globally threatened conservation status. Previous years' wintering studies at SNWF have been reported and presented for download on the AES SNWF website.

To date, as documented by previous reports, there have been no indications that SNWF has had any adverse impact on wintering geese, including RBG, and the more abundant Greater White-fronted Goose *Anser albifrons* (GWFG). This report presents the latest findings, from the 2012/13 winter, which continued to scrutinise the possibility of an adverse impact on wintering geese through SNWF's operation. This report also analyses the risk of collision with turbine blades across the study period, to date.

Methods

Methods were essentially the same as in previous winter surveys. Data were collected within a 'core study area' that encompassed an area centred on the SNWF wind farm, but with additional areas in a buffer in the vicinity of the wind farm (Figure 1): this is to distinguish this area of consistent effort across winters from a much wider area where observations were also undertaken, in some previous winters, that extended north, up the coast to the freshwater lake of Durankulak (see report for the 2010/11 winter). The 'footprint' of the SNWF wind farm, prescribed by a perimeter around the outermost turbines, is referred to as the 'SNWF territory' (also referred to as the Project Area in some previous reports). The 75 days of the study encompassed the whole period when geese were recorded in the core study area, including the SNWF territory, during 2012/13. Detailed observations were made daily, so far as possible within the constraints of suitable weather, on the location and counts (including species composition) of birds involved in flight activity and feeding behavior of any flocks within the wind farm and its vicinity. Crop types within the core study area were also recorded (Figure 1). Observation points and the location and coverage of the BirdScan radar were as in the most recent previous winters (Figure 2)

Searches under turbines for collision victims were changed from the 4 d protocol of the previous two winters to a 7 d search interval. This change was governed by practicalities and that no goose collision casualties had been recorded under the more intensive search protocol of the previous two winters.

Additional novel procedures involved the use of GPS units to allow tracking and recording of search paths when observers were searching for collision victims under turbines.

A detailed description of methods underlying the decisions and procedures for switching off turbines under the (Turbine Shutdown System: TSS) presenting a risk of bird collisions is described in a number of previous reports and in the Owner Ornithological Monitoring Plan. The feeding grounds within the wind park territory identified in the winter surveys were investigated daily and the number of feeding geese at these sites and weather conditions (i.e. heavy mist, fog) were the bases of decisions for the TSS (Turbine Shutdown System) for reduction of the collision risk; as in previous winters.

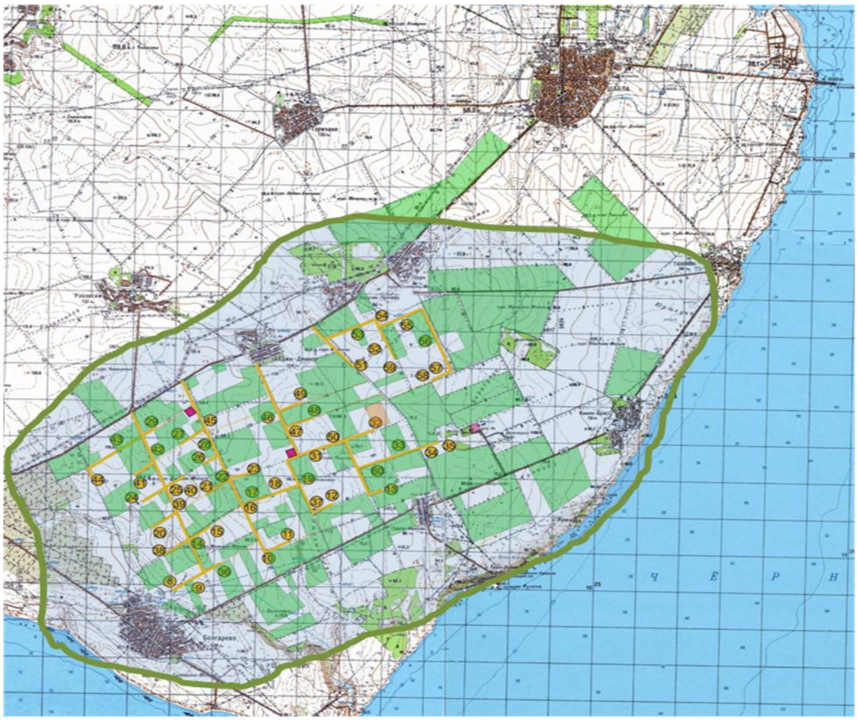

Figure 1. Map of the fields potentially suitable for feeding of geese in winter 2012 – 2013 (green = wheat), and core study area monitored in winter seasons 2009 – 2013 (dark green boundary).

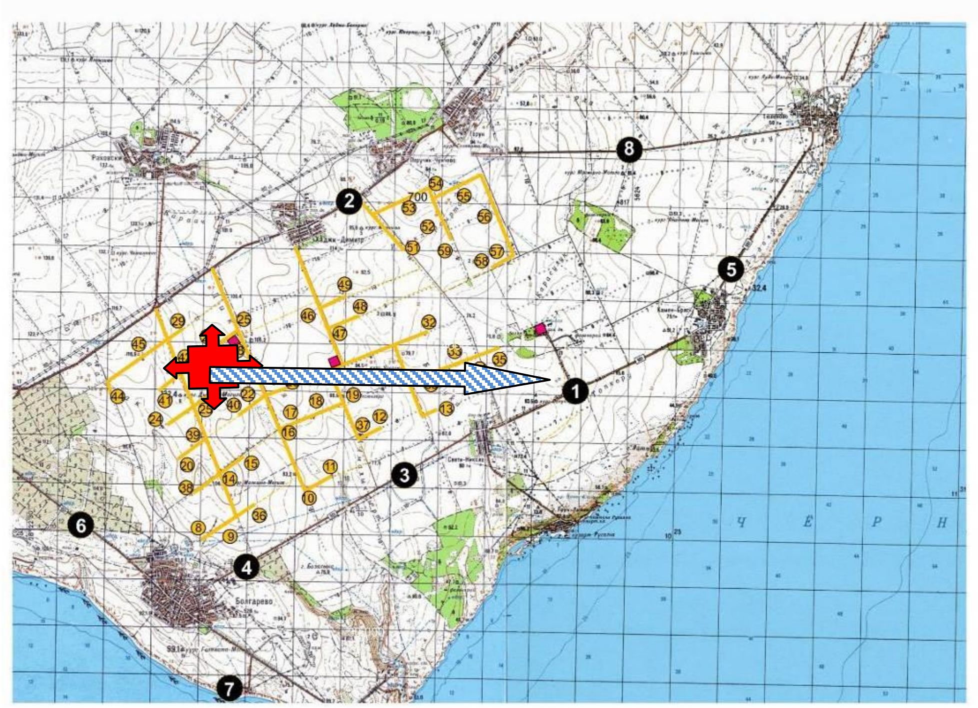

Figure 2. Location and coverage of the BirdScan Radar System during winter monitoring, 2012/2013. The numbered black dots represent visual observation points.

As noted in previous reports, despite the experience and qualifications of all field ornithologists, geese were not always easily identified to species in all circumstances, even when visibility and distance allowed confirmation of overall counts of geese (see Photos 1-3, below).

Photo Strahil Peev

Photo 1. Identification of RBG *Branta ruficollis* and GWFG *Anser albifrons* when in mixed flocks feeding within and in the vicinity of SNWF is the most precise method for quantitative analysis of the relative abundance of the two species.

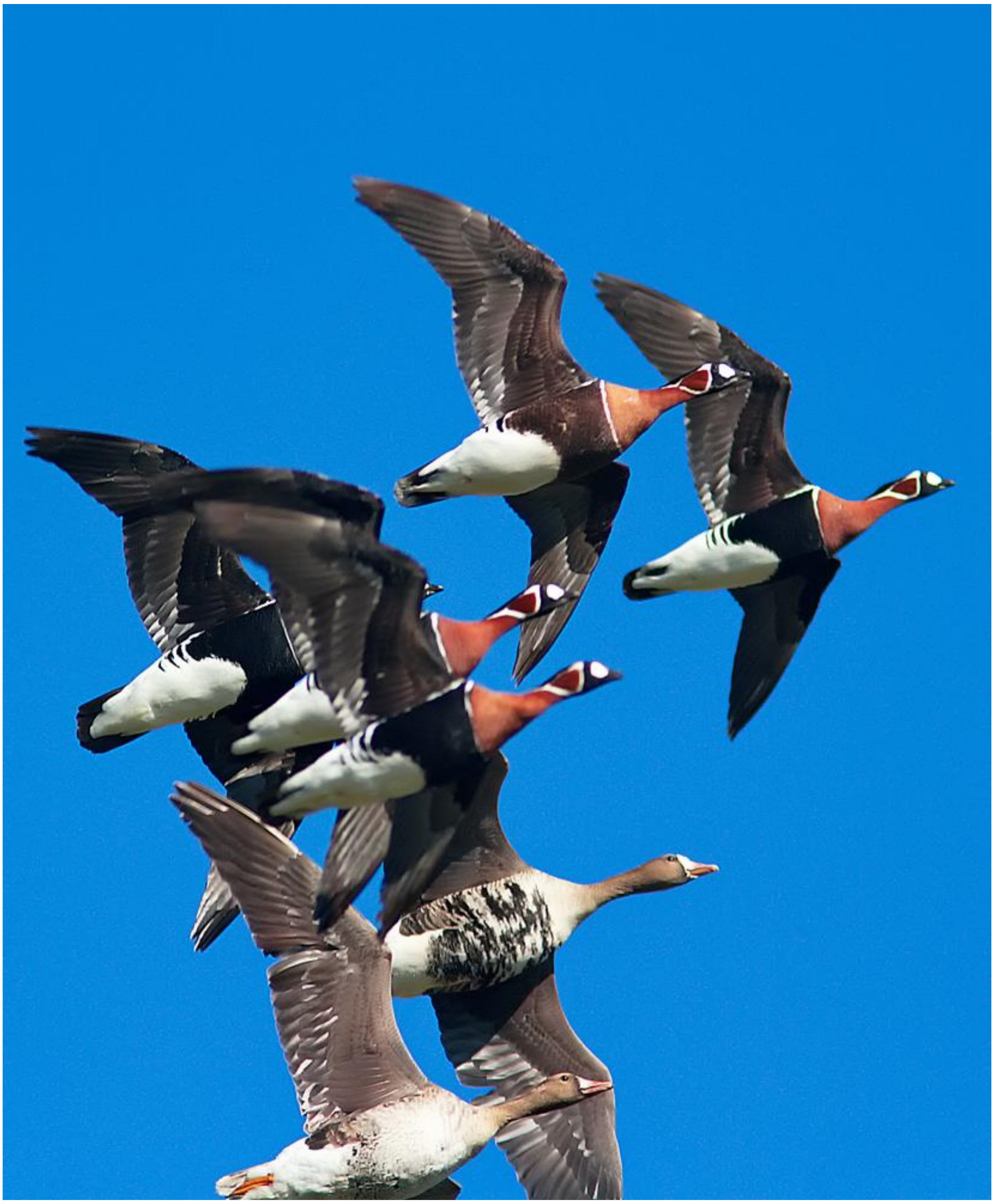

Photo Victor Vasilev

Photo 2. Identification of RBG *Branta ruficollis* and GWFG *Anser albifrons* under good visibility and close proximity is easy; even when in flight.

Photo Victor Vasilev

Photo 3. Identification of RBG *Branta ruficollis* and GWFG *Anser albifrons* from a distance of several hundred metres when in mixed flocks and in rapid flight can be problematic for observers (and impossible for the radar).

List of participants in the observations

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Yanko Sabev Yankov
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Stefan Milenov Dimov
Field assistant

Results

Geese were observed in the core study area between 03 January 2012 and 10 February 2013. The number of birds per species, accepting the difficulty in species identification under distance, flock size and rapid flight activity constraints is presented in Table 1.
Typical for the season, birds of prey were observed in the core study area in similar numbers as previous winter surveys. Single individuals were seen of: Buzzards (*Buteo buteo*), and Rough-legged Buzzard (*Buteo lagopus*). Hen harrier (*Circus cyaneus*), Kestrels (*Falco tinnunculus*) and Sparrowhawks (*Accipiter nisus*) were observed only in January. Four White-tailed Eagle (*Haliaeetus albicilla*): three adults and one subadult bird were observed during the winter monitoring. Within passerine birds, Corn buntings (*Miliaria calandra*) and Brambling (*Fringilla montifringilla*) were the most numerous.

Table 1. The number of observed birds of different species in the core study area monitored in winter season 2012 - 2013 (data from visual observations Figures 1 and 2).

Species	**January**	**February**	**Total**
A. anser	15		15
A. albifrons	224894	2753	227647
B. ruficollis	28317	3590	31907
Anser/Branta	424731	23135	447866
A. nisus	1		1
A. otus	1		1
A. flammeus		1	1
B. buteo	19		19
B. lagopus	3		3
C. carduelis	75		75
C. cyaneus	12		12

Species	January	February	Total
C. cygnus	70		70
C. olor	148	42	190
C. palumbus	30		30
Cygnus sp.	8	10	18
F. columbarius	3		3
F. montifringilla	50		50
F. peregrinus		2	2
F. peregrinus/cherrug	1		1
F. tinnunculus	4		4
H. albicilla	2	2	4
Mil. calandra	220		220
P. pica	14		14
Perdix perdix	11		11
S. vulgaris	24		24
Grand Total	678653	29535	708188

Total number of observed goose species and their numbers

In total, three species of goose were observed in winter 2012/2013: RBG, GWFG and Greylag Goose (*Anser anser*). Over 707,000 individual goose observations were recorded during the surveys in the core study area (Table 1) with less recorded within the smaller SNWF territory (Table 2). No Lesser White-fronted Geese were seen. Additionally Mute Swans (*Cygnus olor*) and Whooper Swans (*Cygnus cygnus*) were observed in the core study area (Table 1) in small numbers: 70 and 190 respectively.

Table 2. The number of observed geese of different species feeding in the SNWF territory (data from visual observations).

Species	January	February	Total
A. albifrons	97621	840	98461
A. anser	4		4
Anser/Branta	77760	13110	90870
B. ruficollis	11205	2490	13695
Grand Total	186590	16440	203030

The recorded numbers of feeding geese of all species in SNWF territory varied during the season with short periods of maximum per species. The maximum of RBG feeding in SNWF were observed between 13 and 17 of January while most GWFG (over 50%) were seen between 23 and 27 of January (Figure 3).

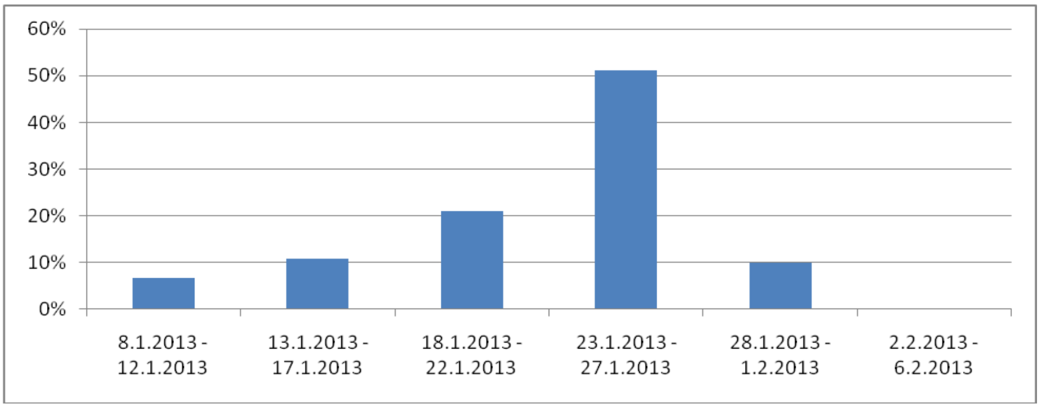

Figure 3a. Seasonal dynamics of feeding GWFG as observed in the SNWF territory in winter 2012/2013

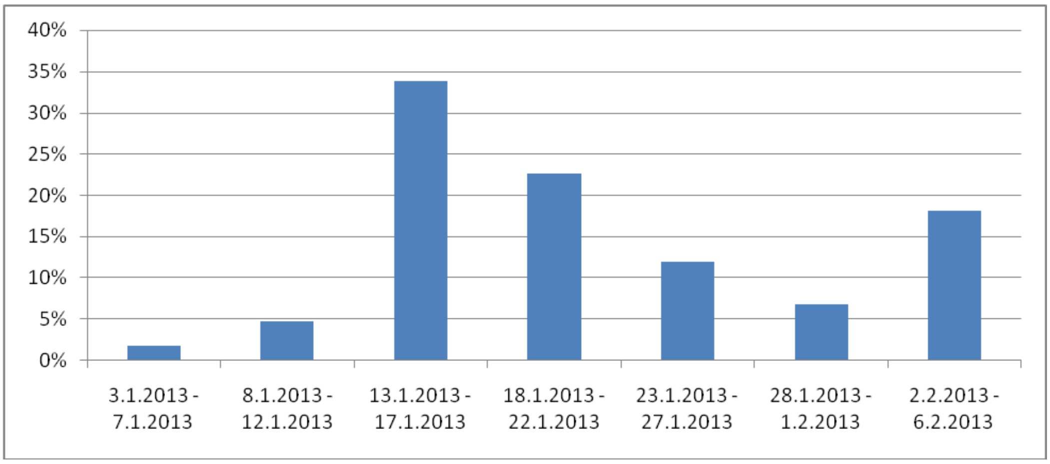

Figure 3b. Seasonal dynamics of feeding RBG as observed in the SNWF territory in winter 2012/2013

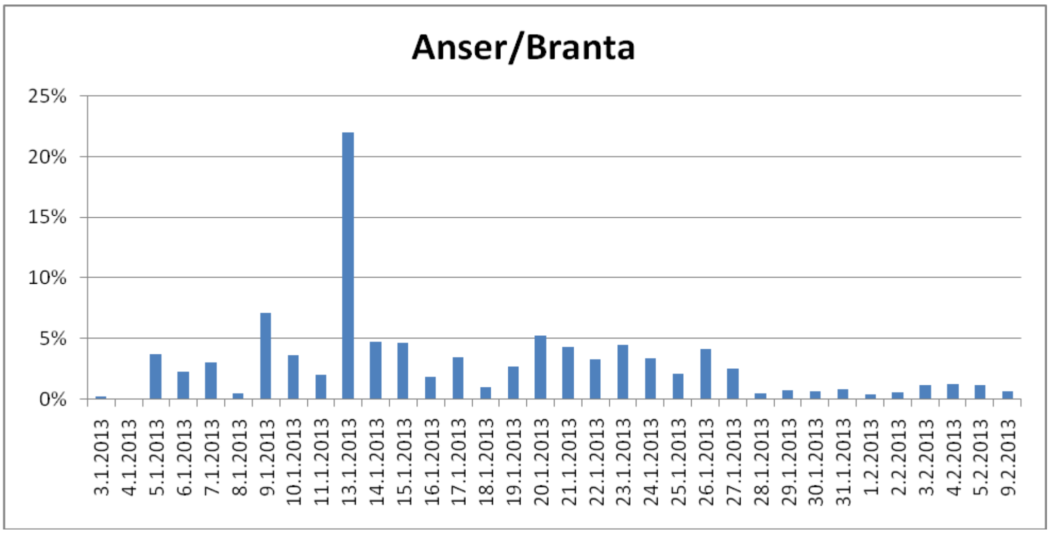

Figure 3c. Seasonal dynamics of all species of geese (in mixed flocks) as observed in the SNWF territory in winter 2012/2013

The peak number of geese (in mixed flocks) was observed in middle of January (13th January). The 'absence' of geese on 12 of January was actually due to fog and reduced ability to detect birds while in the period 6 - 8 February no geese were registered despite good visibility. In general geese were present in similar number in the period 05 – 27 January with a significant increase of three times in two days when over 20% of all geese were observed. The maximum number of RBG (peak count: i.e. the maximum number recorded on any one day within a winter) observed in the core study area (Figure 1) according to the monitoring results in the period 2008 – 2013 are presented in Table 3.

Table 3. The peak counts of RBG in the core study area in five winter seasons

Winter	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013
B. ruficollis	5400	19600	8000	12000	8600

Long term monitoring data from the core study area allows comparison between winter seasons of the last five years (Table 3). The average peak count of RBG feeding in the core study area across five winter seasons was around 10000 birds with no significant trend across the period (Figure 4).

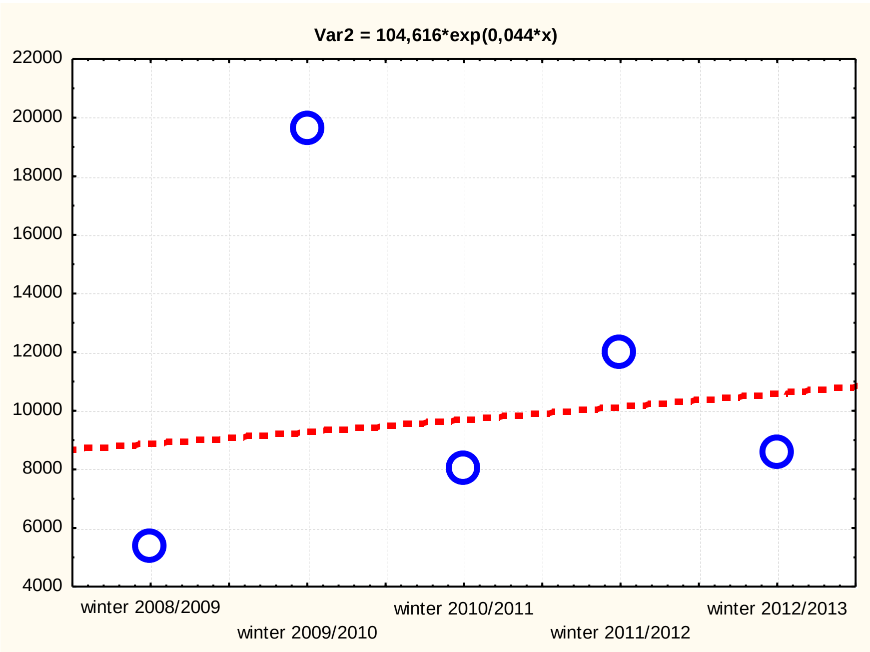

Figure 4. Annual peak counts of feeding RBG as observed in the core study area in the winters 2008 – 2013.

Spatial distribution of feeding geese in the wind farm territory

Day by day appearance in the feeding grounds in SNWF territory and movements of the geese within the wind park territory are given in detail in the Appendix at the end of this report. The main feeding sites in the SNWF territory and the wider core study area on the day when the peak counts of RBG were recorded are presented in Figure 5. Numbers of flights and 'landed' geese (those seen to land and thereafter usually feed), within the wind farm (SNWF territory) or outside the wind farm (but within the core study area) across the 2012/13 winter, are presented in Table 4.

Table 4. Day by day numbers of flights and 'landed' geese (RBG and GWFG) in the core study area, differentiated by whether they occurred within or outside the SNWF territory (i.e. within or outside of the wind farm). 'Landed' geese are those that were seen to land (usually followed by feeding).

Date	Flights inside SNWF	Landed inside SNWF	Flights outside SNWF	Landed outside SNWF
3.1.2013	0	0	1800	0
4.1.2013	0	0	235	0
5.1.2013	98	0	335	9000
6.1.2013	0	6000	5290	4500
7.1.2013	2135	5500	8645	0
8.1.2013	0	0	840	1650
9.1.2013	2680	13600	10740	0
10.1.2013	6600	9300	10060	5000
11.1.2013	8500	8500	8900	0
12.1.2013	450	50	200	0
13.1.2013	8100	1500	92880	16700
14.1.2013	2940	24500	19205	2000
15.1.2013	4555	10700	14495	4500
16.1.2013	925	4700	5345	0
17.1.2013	0	7280	13225	2200
18.1.2013	11650	11800	2320	0
19.1.2013	1960	9300	8700	0
20.1.2013	1550	11000	21450	0
21.1.2013	575	10335	10560	0
22.1.2013	370	0	16380	16350
23.1.2013	200	0	20320	20400
24.1.2013	15000	15000	15100	0
25.1.2013	0	9450	9450	0
26.1.2013	5340	8800	2570	0
27.1.2013	9100	7570	9610	1080
28.1.2013	5324	4924	670	0
29.1.2013	1113	1500	1240	500
30.1.2013	3915	4800	420	0

Date	Flights inside SNWF	Landed inside SNWF	Flights outside SNWF	Landed outside SNWF
31.1.2013	2405	2465	0	0
1.2.2013	0	0	1910	0
2.2.2013	0	3000	2845	0
3.2.2013	0	3000	5296	0
4.2.2013	40	3000	3490	0
5.2.2013	0	2000	2080	4400
6.2.2013	0	0	42	0
7.2.2013	0	0	0	0
8.2.2013	0	0	0	0
9.2.2013	1410	1410	1410	0
10.2.2013	0	70	70	0

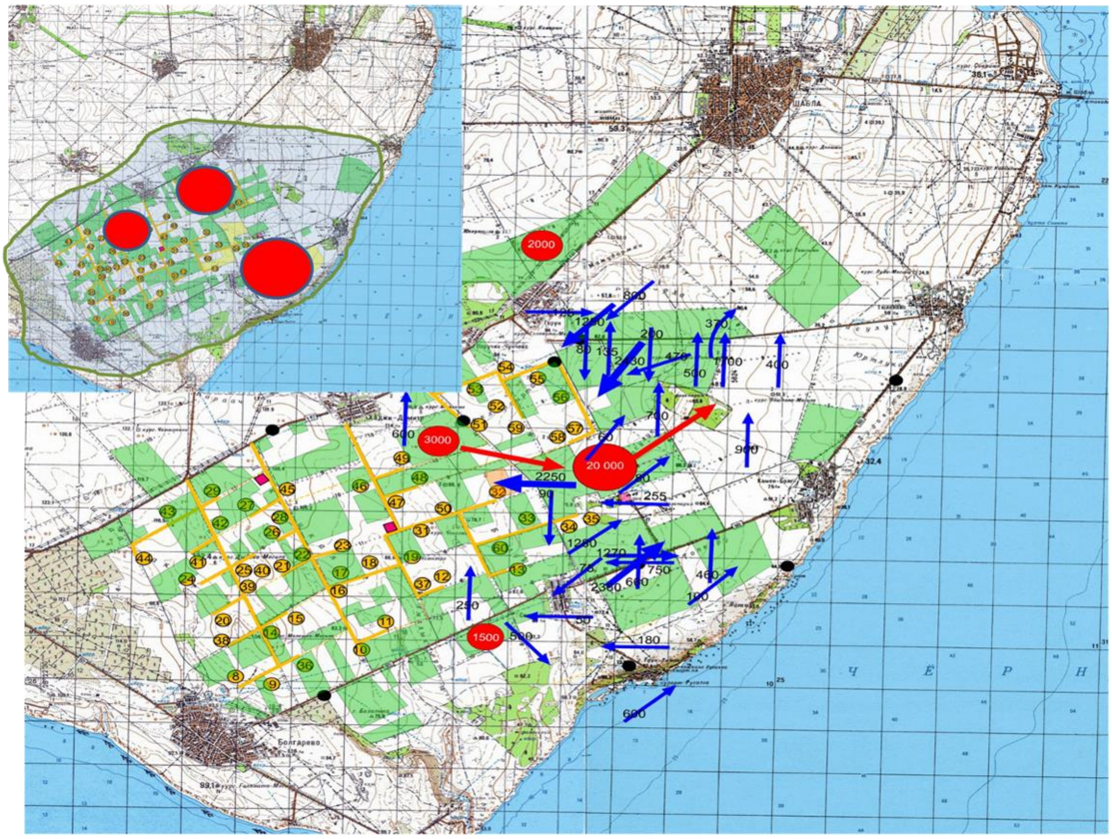

Figure 5. Distribution of mixed flocks of GWFG and RBG in the core study area as observed on the day (14.01.2013) with the peak counts of both species in winter 2012 – 2013. The red colour represents feeding grounds and evening flights, the blue colour represents morning movements. In the left upper corner: main feeding grounds in season 2011 – 2012.

The difference in the spatial distribution of geese in winter 2012/2013 was obviously dependent on the crop distribution in SNWF and surrounding territories (see Figure 5).

The observed flight directions in the mornings, when geese will have been coming from the roosting sites, confirmed previous observations (see reports of previous winters 2008/09, 2009/10, 2010/11 and 2011/12) that there has been a change in the behaviour of the geese to roost in high numbers in the Black Sea along the coast and not in ‘typical’ freshwater roost sites to the north of the Project area. A major proportion of flights of geese incoming to the study area was along E-W axis in the periods when geese were abundant in winter of 2012/13. Use of the freshwater lakes to the north would have resulted in more incoming flights on the N-S axis.

The records collected in the last four winter seasons strongly suggested that many geese were roosting on the sea. Such behaviour, observed for the last several years, is probably a result of increasing long term hunting pressure and disturbance for decades in the previously known main roosting sites – lakes Durankulak, Tuzla and Shabla.

Comparison of the results after five winter seasons of monitoring in SNWF territory after construction of the wind farm with the distribution of geese in the period 1995 – 2000 (Report of BSPB: Dereliev, S. 2000. Results from the monitoring of wintering geese in the region of lakes Durankulak and Shabla for the period 1995-2000. BSBCP & BSPB/BirdLife Bulgaria), when no wind farms were constructed in the region, does not indicate any displacement of geese as a result of the operation of SNWF (Figures 6-8).

It is apparent from Dereliev (2000) that during 1995 – 2000 the core study area was used by geese only in 3 out of the 5 seasons investigated, and the SNWF territory was used in only 1 of the 5 seasons i.e. it was not a permanent feeding area for RBG. In the winters when geese were observed in the present territory of SNWF the localities are largely coincident with the present ones and slight variations can most likely be explained by changes in the crops within the same area. The results obtained immediately before and after the operation of SNWF do not indicate an adverse effect of the wind farm on the winter distributions of feeding geese including RBG. Large numbers of RBG and GWFG were observed within the vicinity of SNWF in every winter season (Table 3), and whilst the number that entered the wind farm itself was variable between winters, there was no indication that the presence of the wind farm either affected goose flight paths or their use of feeding grounds. The annual variation post-construction is to be expected given the observations of comparable annual variation before the presence of SNWF, and given the influence of widespread factors (notably, weather) and more local factors (e.g. crops, hunting activity). The day by day distributions of feeding geese in SNWF territory and the wider core study area for the winter 2012/2013 is given in the APPENDIX: relatively more geese were recorded feeding within the turbine locations in 2012/13 than in the previous four winters (including the 2008/09 winter when no turbines were present).

Figure 6. Localities of feeding geese in winter season 1995– 1996 according to Report of BSPB (Dereliev, 2000) and the core study area (green line) with feeding grounds (blue cycles) established during the monitoring 2008 - 2013

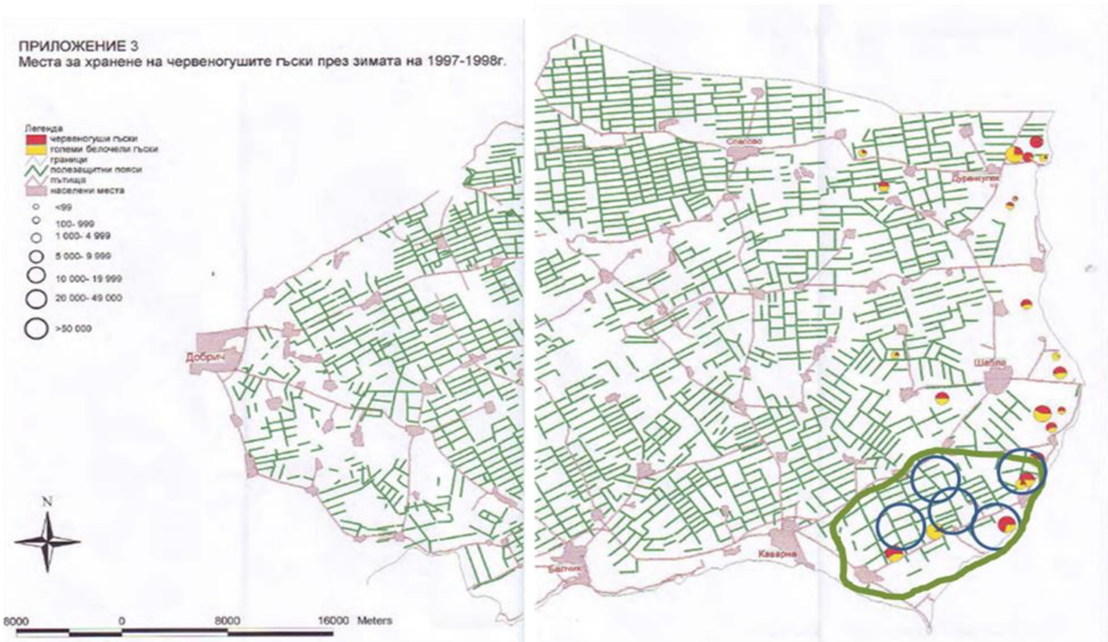

Figure 7. Localities of feeding geese in winter season 1997– 1998 according to Report of BSPB (Dereliev, 2000) and the core study area (green line) with feeding grounds (blue circles) established during the monitoring 2008 – 2013

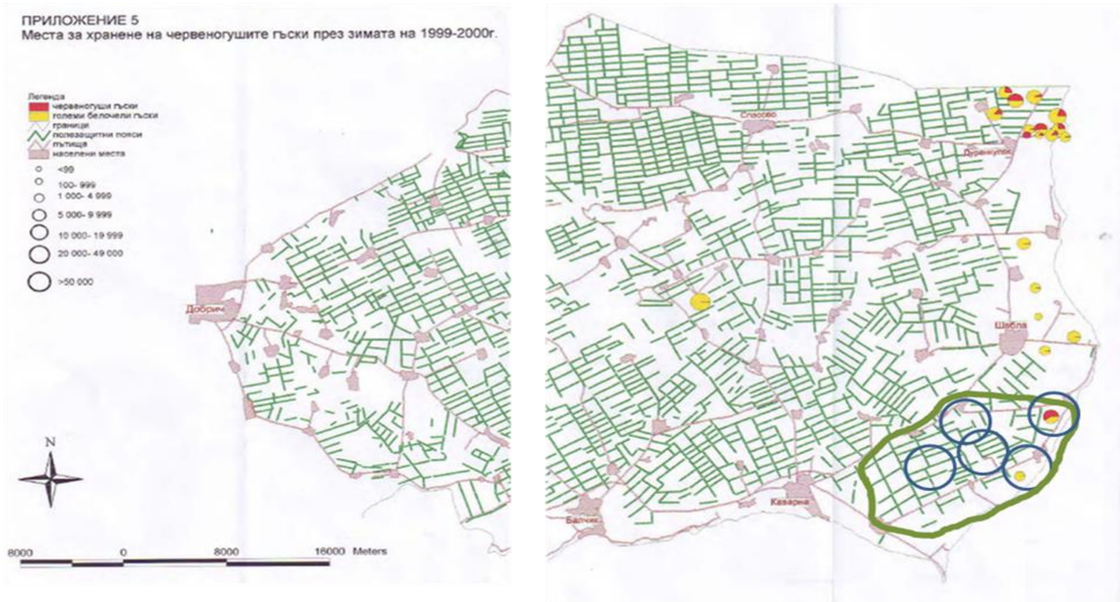

Figure 8. Localities of feeding geese in winter season 1999– 2000 according to Report of BSPB (Dereliev, 2000) and the core study area (green line) with feeding grounds(blue circles) established during the monitoring 2008 - 2013

Altitudinal distribution of flying geese

627,345 observations of geese were available for the analysis of the visually observed flight altitudes in winter 2012/2013. This analysis includes birds observed during all hours of the day and therefore all kinds of functional flights and the whole spectrum of spatial trends seen during the winter season 2012/13.

In contrast to the previous years more birds were observed flying lower, at altitudes between 0 and 50 metres above ground level (Table 5). There is no statistically significant difference in the flight altitudes between RBG and GWFG in the flight altitudes documented in Table 5.

Table 5. Comparative distribution of the flight altitudes of geese observed in the SNWF territory from the vantage points (N = 627,345 birds).

Altitude band (m)	A. albifrons	Anser/Branta	B. ruficollis	Total
0-49	36%	35%	26%	35%
50-99	34%	23%	40%	27%
100-149	14%	10%	18%	11%
150-199	7%	14%	9%	12%
200-249	6%	17%	4%	13%
250-299	1%	1%	1%	1%
300-349	0%	1%	1%	1%
350-400	0%	0%	0%	0%

Diurnal variation in flight activity

According to data from visual observations, the peak of flight activity occurred early in the day, as in winter 2008/9, 2009/10, 2010/11 and 2011/2012 (Figure 9). The geese arrived from their nocturnal roost sites in the first two hours after sunrise. The clear 'departure' peak occurs in 17 h around an hour before sunset, depending on the period in winter. Very low activity, limited to the first two hours after sunset was registered by radar at the wind park territory when only single birds and small flocks were detected. An exploration to find whether there are species dependent patterns in diurnal activity is presented in Figure 10. As in previous years there are no marked differences between the species. The inferred slight differences most probably reflect limitations related to the identification of the species under limited visibility in early morning and late evening periods.

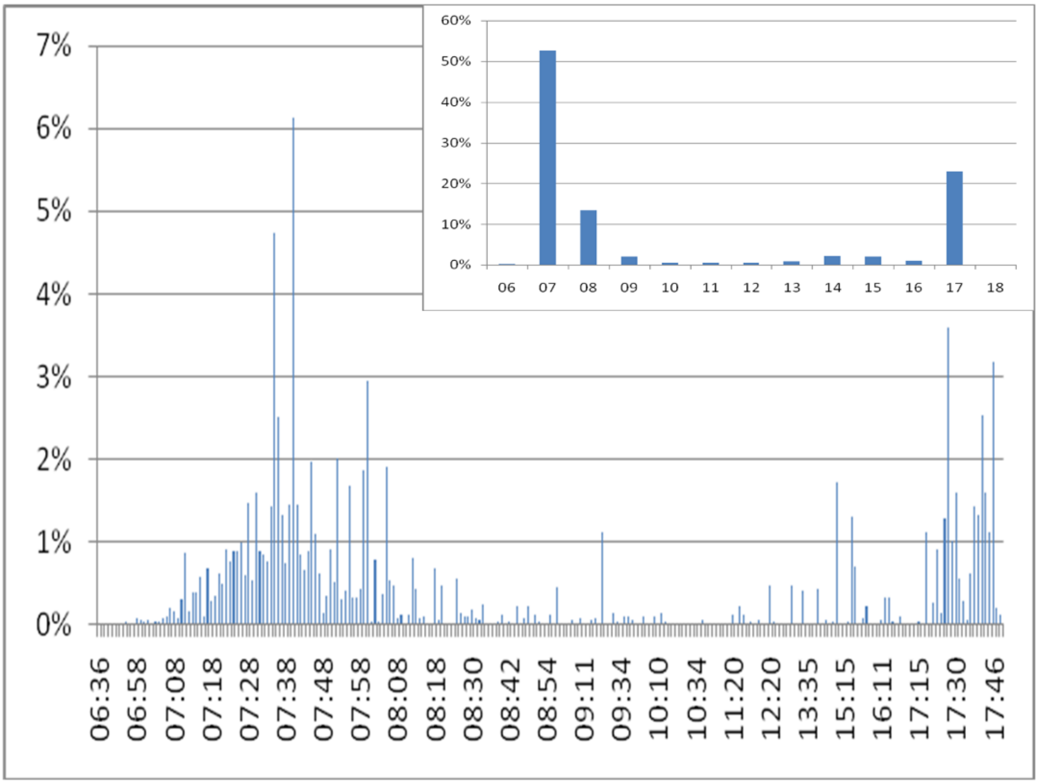

Figure 9. Circadian dynamics of flying geese through the core study area as registered by visual observations in the winter season of 2012/13 (x axis gives time of day (by hour), y axis gives proportion of observations). The same data grouped by hour of the day is presented in right upper corner.

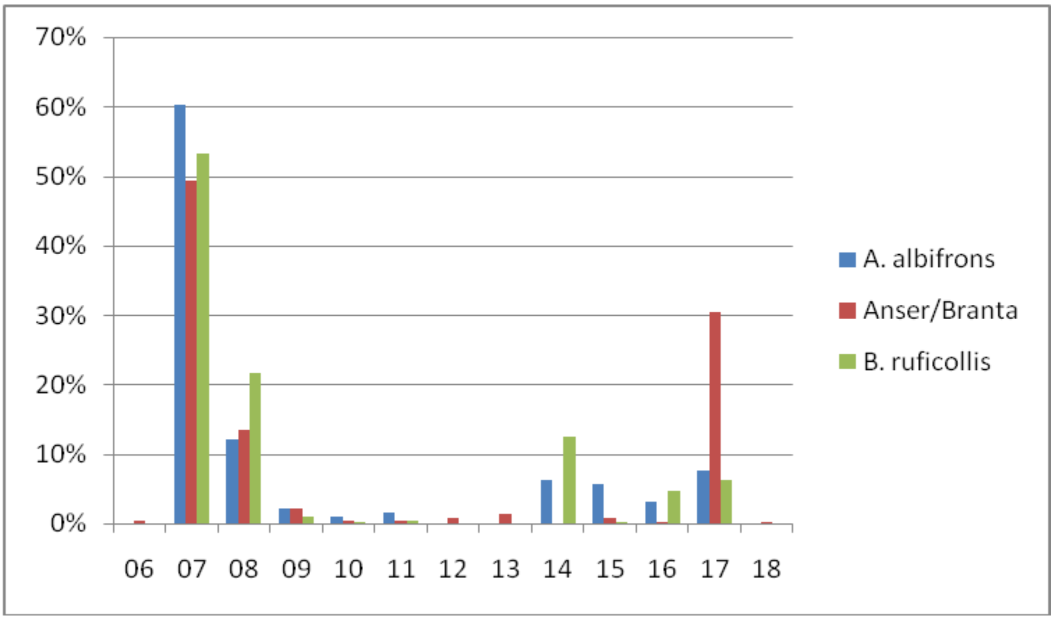

Figure 10. Circadian dynamics of different species through the core study area as registered by visual observations in the winter season of 2012/13 (x axis gives time of day (by hour), y axis gives proportion of observations).

Carcass monitoring results

All 52 turbines were searched every seventh day for carcasses during the whole winter survey period (01 December 2012 – 15 March 2013). The frequency of searches as well as names of the field ornithologists involved in the survey is presented in Table 3. The main limitation on programmed searches in the study period was the restricted access because of weather conditions: mostly deep snow cover or thick mud. In such situations the plots of 200 x 200 metres under turbines were searched from the turbine base (stairs and platform around 3 metres high) by binoculars. Over 95 % of the programmed searches under the 7 day-interval protocol using walked transects in the 200 x 200 metres plots were completed.

Standard tracks logged by GPS used for recording carcass searches are presented in Figure 11.

Figure 11. The GPS track of the weekly transects repeated four times per month during the monitoring period.

Table 6. The numbers of turbines searched for collision victims in winter season 2012/2013 by different searchers.

Turbine	Kiril Bedev	Strahil Peev	Stefan Dimov	Victor Vasilev	Yanko Yankov	Total
8	6	1	1	1	5	14
9	6	1	2	1	5	15
10	7	1	2	2	4	16
11	5	1	1	2	5	14
12	6	1	1	1	4	13
13	6	1	2	2	4	15
14	6	1	1	3	5	16
15	7	1	2	1	5	16
16	7	1	2	2	5	17
17	6	1	1	2	4	14
18	6	1	1	2	4	14
19	6	1	2	1	4	14
20	6	1	2	2	4	15
21	6	1	2	3	5	17
22	6	1	2	3	4	16
23	5	1	2	2	4	14
24	5	1	1	2	5	14
25	6	1	1	2	5	15
26	5	1	1	2	4	13
27	5	1	2	4	5	17

Turbine	Kiril Bedev	Strahil Peev	Stefan Dimov	Victor Vasilev	Yanko Yankov	Total
28	6	1	2	3	4	16
29	6	1	1	2	5	15
31	7	1	1	2	4	15
32	4	1	2	2	4	13
33	5	1	2	2	4	14
34	6	1	2	2	4	15
35	5	1	2	2	4	14
36	6	1	1	1	5	14
37	6	1	2	1	4	14
38	6	1	1	2	5	15
39	6	1	2	2	4	15
40	6	1	1	1	6	15
41	5	1	2	2	4	14
42	6	1	2	2	4	15
43	7	1	1	2	5	16
44	6	1	1	2	5	15
45	6	1	2	3	4	16
46	6	1	1	2	4	14
47	7	1	2	2	4	16
48	6	1	2	2	4	15
49	5	1	1	2	4	13
50	6	1	2	1	4	14
51	6	1	1	1	3	12
52	5	1	1	1	3	11
53	6	1	2	2	3	14
54	6	1	2	1	3	13
55	6	1	2	1	3	13
56	5	1	3	1	4	14
57	5	1	2	1	4	13
58	5	1	1	1	4	12
59	6	1	1	1	3	12
60	7	1	1	2	4	15
Total	**304**	**52**	**82**	**94**	**219**	**751**

There was one intact carcass found in 2012/13 winter season: a Great Crested Grebe (*Podiceps cristatus*) was found dead under turbine 27 on 12 March 2013 at 66m distance in NE direction from the turbine base. Regional Office of the Ministry of Environment and Waters (RIOSV) were informed and they collected the bird for analysis in the same day with protocol NC – 1758/13.03.2013. During initial observation on site a penetration wound was noted under the right wing of the dead bird, that the body was otherwise intact, and no obvious fractures or collision injuries were present. After the detailed analyses done by RIOSV next day it was confirmed that the bird had been attacked by a predator and had not died due to a collision with the turbine.

Table 7. The results of the collision victim monitoring in winter season 2012/2013.

Taxon	Single feather	Bunch of feathers	Intact	Part of the body	Total
Alaudidae		2		1	3
Anser albifrons	1				1
Anser sp.	1				1
Branta ruficollis		2			2
Not identified	22	11			33
Pica pica		1			1
Pluvialis apricaria		1			1
Podiceps cristatus			1		1
Total	**24**	**17**	**1**	**1**	**43**

All other remains found during the winter collision victim monitoring including single feathers, bunches of feathers and body parts (Table 7) also cannot be attributed to collisions with turbines, as they were inconsistent with the volume and form of remains expected from such trauma. This included two bunches of feathers of RBG, as well as a single feather from GWFG.

No parts of the body or intact remains of geese which could definitely be considered as collision victims were detected after 751 single searches of different turbines in the period 01 December 2012 – 15 March 2013 (Tables 6 and 7). Therefore, no evidence for collision of geese species, including RBG, was found in the winter survey period when geese were present.

In order to reduce the risk of collision with the rotors of the wind turbines in conditions of reduced visibility (fog or snowstorm), different groups of turbines as well as single turbines were stopped during the 2012/13 winter study period (see later), as during the previous three winters.

Collision Risk Modelling and Avoidance Rates

Input data

A previous report (report for the 2010/11 winter) explored collision risk modelling for both GWFG and RBG using the 'Band' Collision Risk Model (CRM: Band et al 2007) for the 2010/11 and 2009/10 winters. This exercise is repeated here for the 2012/13 winter, with comparisons made for previous winters and using the data to estimate likely 'avoidance rates' under the Band CRM.

Bird size and flight speed
Measures of body size were taken from Cramp (1998) and flight speed from Campbell & Lack (1985) and Provan & Whitfield (2007) (Table 8).

Table 8. Measures of goose body size and flight speed used in the CRMs.

Measure	RBG	GWFG
Body length (m)	0.55	0.72
Wingspan (m)	1.26	1.49
Flight speed (m/s)	19	19

Wind farm parameters
Input values for parameters relevant to the wind farm specifications are given in Table 9. Note that the proportion of time that turbines were assumed to be operational accounts for ‘downtime’ when blades do not turn due to wind speed and turbine maintenance. The value used in the CRMs is the standard metric calculated by the wind energy industry for modern turbines such as those deployed at SNWF. Observations at SNWF conform to this metric.

Table 9. Input values for wind farm parameters.

Measure	Value	Notes
Number of turbines	52	
Proportion time operational	0.87	Standard industry metric
Rotor diameter (m)	90	Vestas V90 3 MW model
Rotational speed (rpm)	16.1	Variable, but 16.1 nominal speed
Maximum chord (m)	3.5	Vestas V90 3 MW model
Pitch (degrees)	15	Vestas V90 3 MW model
Corridor width (m)	6900	Mean distance across wind farm + 200 m buffer

Goose flight activity parameters
The number of goose flights within the wind farm area was estimated from the number of observations of goose flights across the wind farm and from those records where geese were observed as landing within the wind farm (Table 4). In the 2012/13 winter, due to a greater propensity for birds to feed within the wind farm, rather than simply fly through it, the number of daily flights at risk of collision was taken primarily as being the number of birds observed as landing within the wind farm. Although doubling the number of birds seen landing may be considered a more appropriate method because the birds must have flown in and out of the wind farm, the Band CRM (Band et al 2007) assumes that bird flights pass through the full turbine array and in its current format it is not designed to deal with birds flying in and out of a wind farm. Hence, doubling the number of birds seen landing would imply that the total exposure of flights to the whole array was twice the number seen landing. This is not the case, because each flight (in or out) only exposed the birds to part of the array. Taking only the number of birds seen landing as being a measure of the number of ‘at risk’ flights therefore represents a compromise that better fits the model’s assumptions, since it was not possible to construct a more bespoke version of the Band CRM because the directions which feeding birds had taken when entering

and/or leaving the wind farm (and so the number of turbines the birds had negotiated) were often unknown.

If a smaller number of birds were also observed flying through the wind farm, then these were ignored as they may have been a component of the birds seen to land within the wind farm. This is a conservative measure in terms of estimating the collision risk, since not all flights through the wind farm will involve birds moving in to feed within the turbines i.e. it probably underestimated the predicted collision mortality, and so the capacity for geese to avoid collision will be underestimated. If the number of birds observed flying across the wind farm exceeded the number observed to land then these records were added to the number of flights at risk after accounting for the numbers that must have flown in/out to feed after landing. Finally, if there were no records of birds landing within the turbines on a day when birds were observed to fly through the wind farm then the number of flights through was taken as the number of flights at risk.

As in previous years, the goose flights at risk according to species were taken from daily records of numbers of identifiable species, as the presence of the two species varied within a season. In other words, while records of ‘at risk’ flights included ‘Anser/Branta’ records, the number of flights that were attributed to each species were based on daily records of the proportion of each species – GWFG or RBG.

Since there was no marked observed species difference in flight altitude between species across the years (unsurprising as mixed species flocks were the norm) the proportion of flights at risk height altitude was taken from the summed observed goose records (i.e. the ‘Total’ column in Table 5) Given species-specific values (Table 5) this procedure was conservative as regards the number of expected collision victims. Past analysis has shown that these observed records do not differ substantially from the more precise radar records of altitude.

With a turbine hub height of 105 m and a rotor diameter of 90 m, the rotor swept height (RSH) which presented a risk of collision was 60 – 150 m. Conservatively, as in previous reports, the ‘at risk’ altitude of flights, according to the records of flight altitude bands recorded, was taken to be 50 – 149 m. As a conservative (precautionary) measure of flight activity at RSH from the recorded flight heights, the data for the height band 50 – 149 m was employed for all geese observations in 2012/13, giving a value of 0.38 (38 %: Table 5).

In order to reduce the risk of collision with the rotors of the wind turbines during conditions of reduced visibility, different groups of turbines (as well as single turbines) were stopped during the 2012/13 winter. In total there were 173 times when an individual turbine was stopped due to a perceived collision risk for geese, comprising a total of 546 turbine-hours, which represented 3.4 % of the potential diurnal operational turbine-hours when geese were present in the core study area over the study period. In December 2012, no shutdowns were required. In 6 different days in January, 117 of the 173 stops were ordered. On January 12, the entire wind farm was stopped for almost the entire day because of a severe snow storm. In February on three different days 56 stops were ordered. The duration of each stop varied between 20 minutes to 9 hours.

The large majority of flights involving the time when the TSS was implemented were not considered as 'risk flights' in terms of the CRM and as documented by the radar. This was because of the predominant circumstances when the TSS was implemented: during fog or other circumstances of reduced visibility (e.g. snowstorm) when, because both observers and the radar were 'blind', there was uncertainty as to the behaviour of the geese. In both these situations, therefore, no 'at risk' flights were recorded. Consequently, the estimates of number of flights within the wind farm presented in Table 4 (and so the potential numbers of flights to be considered by a CRM) were not markedly affected by the TSS. The number of flights that occurred during such conditions of reduced visibility and TSS implementation was probably small, in the context of the observations of goose flights during turbine operation over the whole winter; as in the previous two winters.

Radar observations indicated that, whilst they occurred, there were relatively few flights of geese during the hours of darkness (see above): not accounting for these few records in the CRM will again make the predictions of collision mortality (and avoidance rate estimation) conservative.

Probability of collision

As described by Band (2001) and Band et al (2007) even if birds fly through spinning rotor blades they will not always be hit by a blade due to the interaction between the movement and metrics of the blades and the movement and metrics of the bird. This ‘probability of collision’ consequently varies according to blade and bird metrics and is calculated using a standard Excel spreadsheet (Band 2001). In the present study the collision probabilities were 8.1 % (RBG) and 9.0 % (GWFG).

Predicted mortality under various avoidance rates

As noted in previous winter reports, the CRM requires the application of a substantial correction factor in order to produce realistic estimates of bird fatality rates. This factor attempts to account for the fact that birds do not simply fly towards rotating blades (as assumed by the unadjusted CRM) but take action to avoid collision, and hence is called the ‘avoidance rate’. As in previous winter reports, CRMs were run using three avoidance rates: 99 %, 99.6 % and 99.9 %; and for each winter of observation since SNWF has been operational i.e. 2009/10, 2010/11, 2011/12 and 2012/13. Estimates of predicted mortality have not been presented in previous reports for the 2011/12 winter. Here we used the same methods as for the 2012/13 winter in estimating the number of goose flights through the wind farm for this winter. In future publications this method will be applied across all winters, and will also be compared with the simpler method of recorded flights only, as used for the 2009/10 and 2010/11 winters.

Estimated avoidance rates

As described above for 2012/13 and for previous winters, there have been no recorded deaths of geese due to collision. Simplistically, it is possible to estimate the probability of zero collisions[1] at any given quantile e.g. 0.05, 0.01 or 0.001, taking the 'unadjusted' (i.e. before application of an avoidance rate) number of flights that the Band CRM predicts should result in a collision: this probability gives the avoidance rate at that quantile, for the Band CRM.

Given that, after accounting for the predictions of the Band CRM, each flight of a bird through moving turbine blades may result in a collision or no collision, then the distribution of the total number of collisions will follow a standard binomial distribution, because each flight is, in essence, a Bernoulli (or binomial) trial (as a bird may be hit by blades or not hit in each flight). The avoidance rate (or more correctly 'true' collision probability) can therefore be determined under the Band CRM that would lead to a zero collision total at a particular quantile of the cumulative binomial distribution[2].

Mathematically, with:

$X \sim Binomial(n, p)$, then the probability of having zero collisions is $\Pr\{X = n\} = p^n$

Given the binomial condition $\alpha \in (0,1)$, then with $\alpha \leq \Pr\{X = n\}$ such that the $(1 - \alpha)$ quantile of X will be equal to n. This can be written as: $p^n \geq \alpha$ Û $p \geq \alpha^{1/n}$.

Therefore, for example, at the 5% (0.05) quantile the lowest probability (avoidance rate) for zero collisions for GWFG in 2010/11 is given by $p = 0.05^{1/1749}$ given that there were 1749 flights of GWFG that should have led to a collision after accounting for predicted collisions under the Band CRM, and zero collisions were recorded.

Analyses were conducted across both species, in all years (and combined years) and at several levels of probability (statistical significance).

Model outputs

Mortality predictions

Predicted collision mortality by winter, species and assumed avoidance rate are given in Table 10.

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[1] This gives results based on zero deaths, as zero deaths have been recorded. The search regime for recording deaths, however, is not perfect and according to previous analyses will detect about 0.5 of all casualties under a 4 d search interval (as in 2010/11 and 2011/12). The search interval in 2012/13 was 7 d, which will reduce the chance of detecting a dead bird further in this winter. These probabilities of detection can potentially be incorporated into the estimation of avoidance rates, but have not been done so here formally. Nevertheless, their influence will be minimal at all levels of analysis.

[2] An avoidance rate under any other CRM could be similarly determined – here the focus is on the Band CRM.

Table 10. Numbers of geese predicted to be killed by collision at SNWF, by species, based on observed flight activity across four winters, and under three CRM avoidance rates.

Winter	**Species**	**Avoidance rate**		
		99 %	99.6 %	99.9 %
2009/10	RBG	8.9	3.6	0.9
	GWFG	86.1	34.4	8.6
2010/11	RBG	1.3	0.5	0.1
	GWFG	17.5	7.0	1.7
2011/12	RBG	4.1	1.7	0.4
	GWFG	15.9	6.3	1.6
2012/13	RBG	6.7	2.7	0.7
	GWFG	35.0	14.0	3.5
All	**RBG**	**21**	**8.5**	**2**
	GWFG	**154**	**62**	**15**

According to these predictions at, for example, a 99 % avoidance rate, there should have been 175 geese killed by collision at SNWF over the four winters of operation. To date no collision casualties have been found by targeted searches or incidental observations during, for example, turbine maintenance.

There were no systematic searches for collision victims in the 2009/10 winter, but even ignoring this winter, 80 collisions were predicted at the 99 % avoidance rate, and eight deaths at the 99.9 % avoidance rate. It is known that the search regime will not discover every collision victim (see 2010/11 winter report) but even accounting for such potential missed victims, it is apparent that the ability of geese to avoid collision is extremely high. This ability is considered further in the next sub-section.

Estimated avoidance rates

The estimated avoidance rates by species and winter, and summed across all winters, are presented in Table 11. As GWFG is the most common species then the level of certainty is greater for this species on likely avoidance rates. Taking all winters combined it can be 99.9 % certain that the avoidance rate of GWFG is over 99.9 %, based on zero mortality (Table 11). Excluding the 2009/10 winter, when no searches for collision victims were conducted, makes little discernible difference to this result. Whilst it is known that some GWFGs may have been killed and not recorded (notably in the 2009/10 winter when no systematic searches were made under turbines) it is also known that the number of 'missed' collision victims will have been very small. That some were missed is less likely given that no victims were recorded at all, despite the relatively frequent searches in three of the winters. Making a further conservative assumption that a small number of collision victims were not discovered (and formally incorporating such a possibility) would make little material difference to the estimated avoidance rates. It is apparent that GWFG have a near-perfect ability to avoid collision with rotating turbine blades at SNWF.

Table 11. Estimated avoidance rates for both goose species under the Band CRM given zero recorded mortality, by winter and at various levels of statistical probability (% quantile).

Winter	Species	Avoidance rate at quantile		
		5 %	1 %	0.1 %
2009/10	RBG	0.9966		
	GWFG	0.9997		
2010/11	RBG	0.9775		
	GWFG	0.9951		
2011/12	RBG	0.9928		
	GWFG	0.9981		
2012/13	RBG	0.9955		
	GWFG	0.9992		
All	**RBG**	**0.9986**	**0.9978**	**0.9967**
	GWFG	**0.9998**	**0.9997**	**0.9996**

For RBG the certainty on the species' capacity to avoid collision is lower, because RBG are less common than GWFG and so there were fewer 'at risk' flights. Nevertheless, it is apparent that there is a 95 % certainty that the avoidance rate of RBG is 99.9 %, and a 99 % certainty that it is 99.8 %. Again, as for GWFG, there is a possibility that some RBG were killed by collision but not discovered. This possibility is much lower than for GWFG, because they were less common, and given that no dead GWFG were found, the possibility of undiscovered RBG is commensurately much smaller.

Conclusions

The methods applied to this study in 2012/13 were similar to those in the winter seasons of 2008/2009, 2009/2010, 2010/2011 and 2011/2012. The comparative approach provided important information concerning the species composition of geese and their spatial and temporal distribution within the Project area in five consecutive winter seasons.

There is no difference in the start and end of the winter periods within all five winter seasons. The temporal dynamics of the presence of geese reflects meteorological conditions in the region and correlates positively with the coldest period of winter. However, there is a definite 'peak' period of activity with a concentration of over 90% of RBG being seen within 20-30 days; this concentration corresponds to the coldest period of the winter in all five surveyed seasons.

The number of goose flights within the wind farm varied across the winters of the study. This partially depended on the time period when the geese were present in the region of NE Bulgaria. It also varied according to the number of flights that passed through the wind farm, and according to the numbers of geese that accessed areas within the wind farm for feeding. These numbers of feeding geese varied across winters, as recorded before SNWF was constructed,

The flight altitudes of the geese from all species observed crossing the Project area were most intensive between 50 and 100 m above ground level in all four winter seasons. There was a slight decrease in the mean altitude of flights in the latest winter (2012/13) which may indicate a habituation process to the presence of turbines in the post-construction period of SNWF, or that SNWF was a particularly attractive area for feeding geese in 2012/13 (and so more low altitude flight records were observed as geese flew in and out from feeding areas within the wind farm).

The 2012/13 winter observations confirmed previous results that the diurnal activity of geese primarily occurs in two periods of intensive flights: morning (7-9 h) and, to a lesser extent, evening (16-18 h). The study in 2012/13 again did not register substantial nocturnal flight activity as was already recorded during the previous two winter surveys.

The 2012/13 winter confirmed, once again, that hunting pressure has probably pushed geese to change their overnight roost sites from their two traditional fresh water lakes to the sea surface in a large area along the Black Sea coast. This pressure has been increasingly observed over the last 10 years with shooting of the wintering geese around the two main fresh water roosting sites lakes Durankulak and Shabla. This will probably have an adverse effect on these wintering geese populations far greater than any effect of SNWF, as it is apparent that SNWF has not prevented geese from using feeding grounds used in the past, or presented a material increased risk of mortality through collision with the turbine blades in accessing these feeding grounds.

No remains of geese that could be attributed to collision with turbine blades were found during several hundred searches per season under operational turbines in three winters' surveys after the wind farm's construction. Predictions of mortality based on high levels of avoidance of collision were not observed. Both geese species clearly have a near-perfect ability to avoid collision with the rotating turbine blades at SNWF. That this capacity can be demonstrated with a high level of statistical certainty also indicates that geese are not averse to flying through or feeding within the wind farm.

There is no evidence of any adverse effect of SNWF on populations of geese species in winter: the presence of the wind farm has apparently not discouraged the use of arable resources by feeding geese and SNWF does not create a material risk of collision mortality. To summarise: to date no geese have apparently died as a result of SNWF and no geese have apparently been prevented from using potential feeding areas within SNWF.

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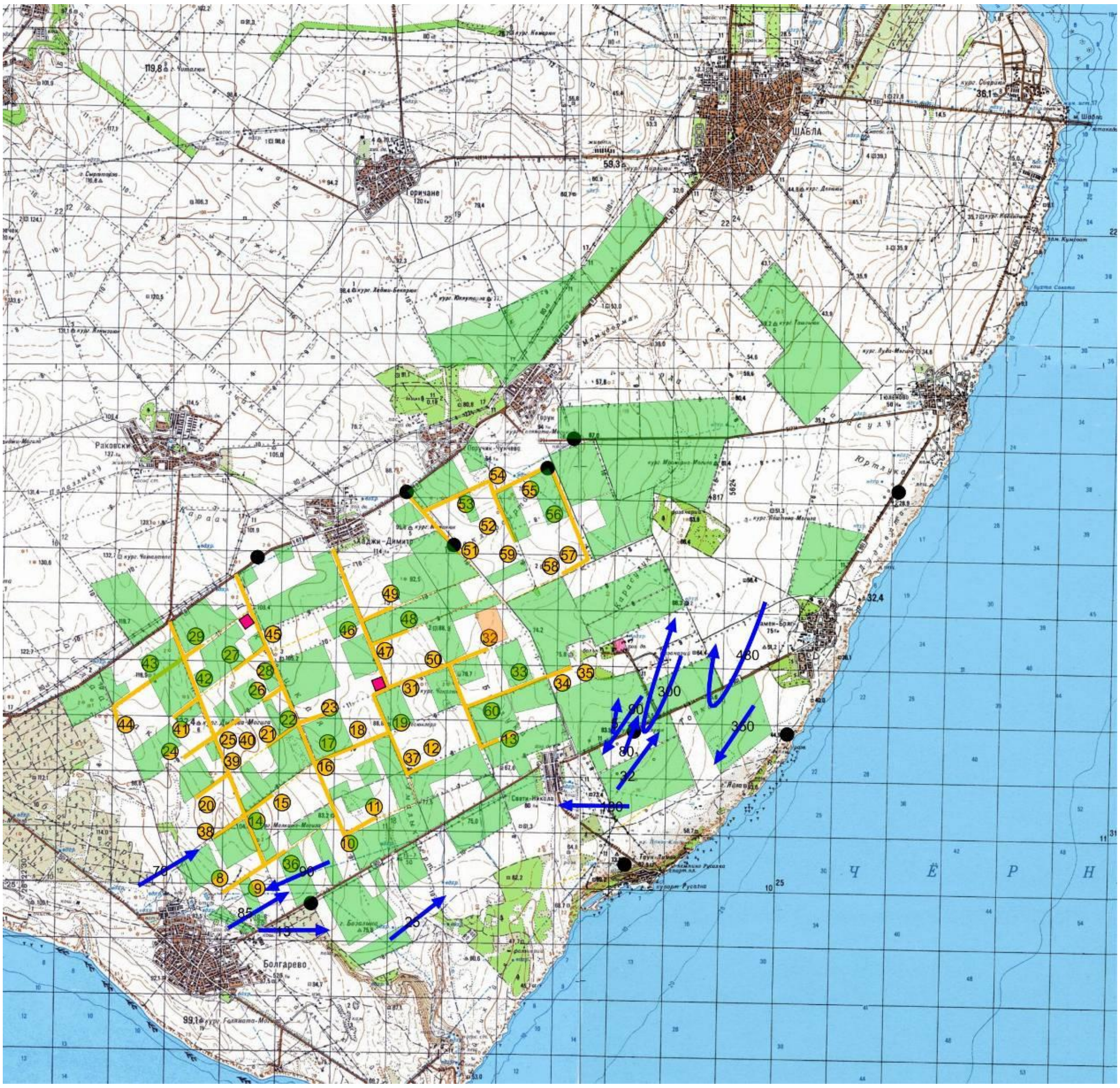
Appendix



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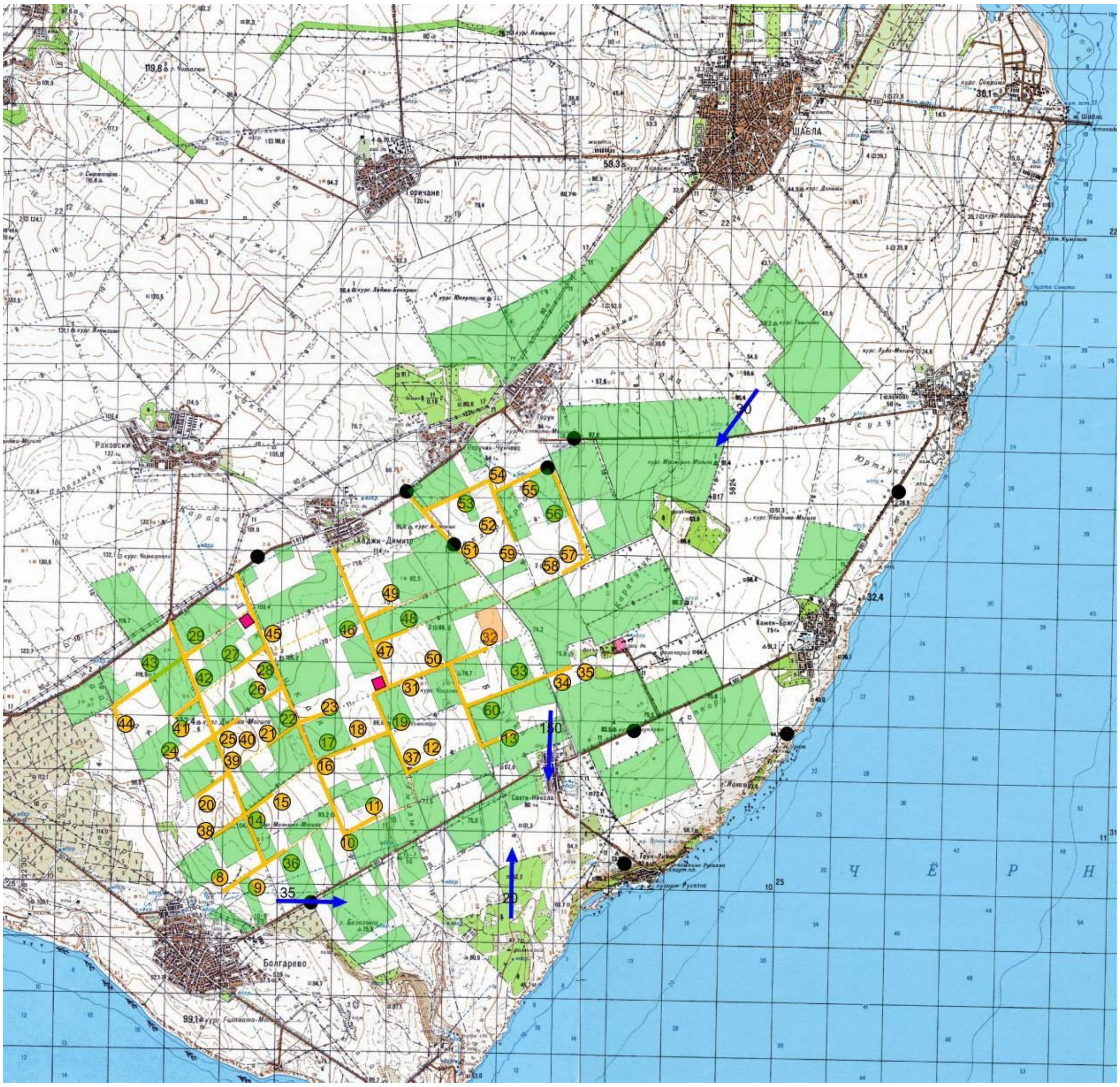

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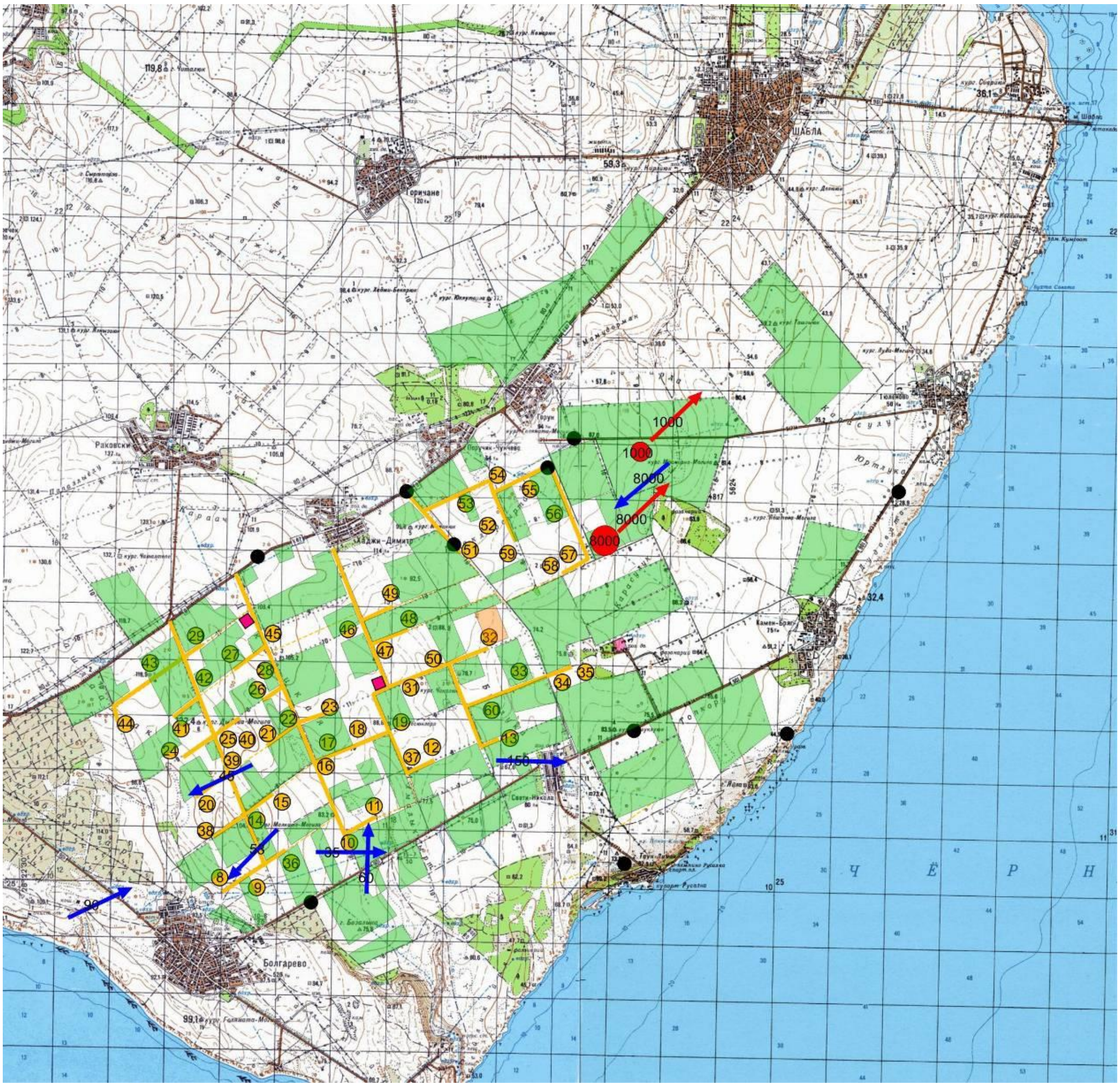

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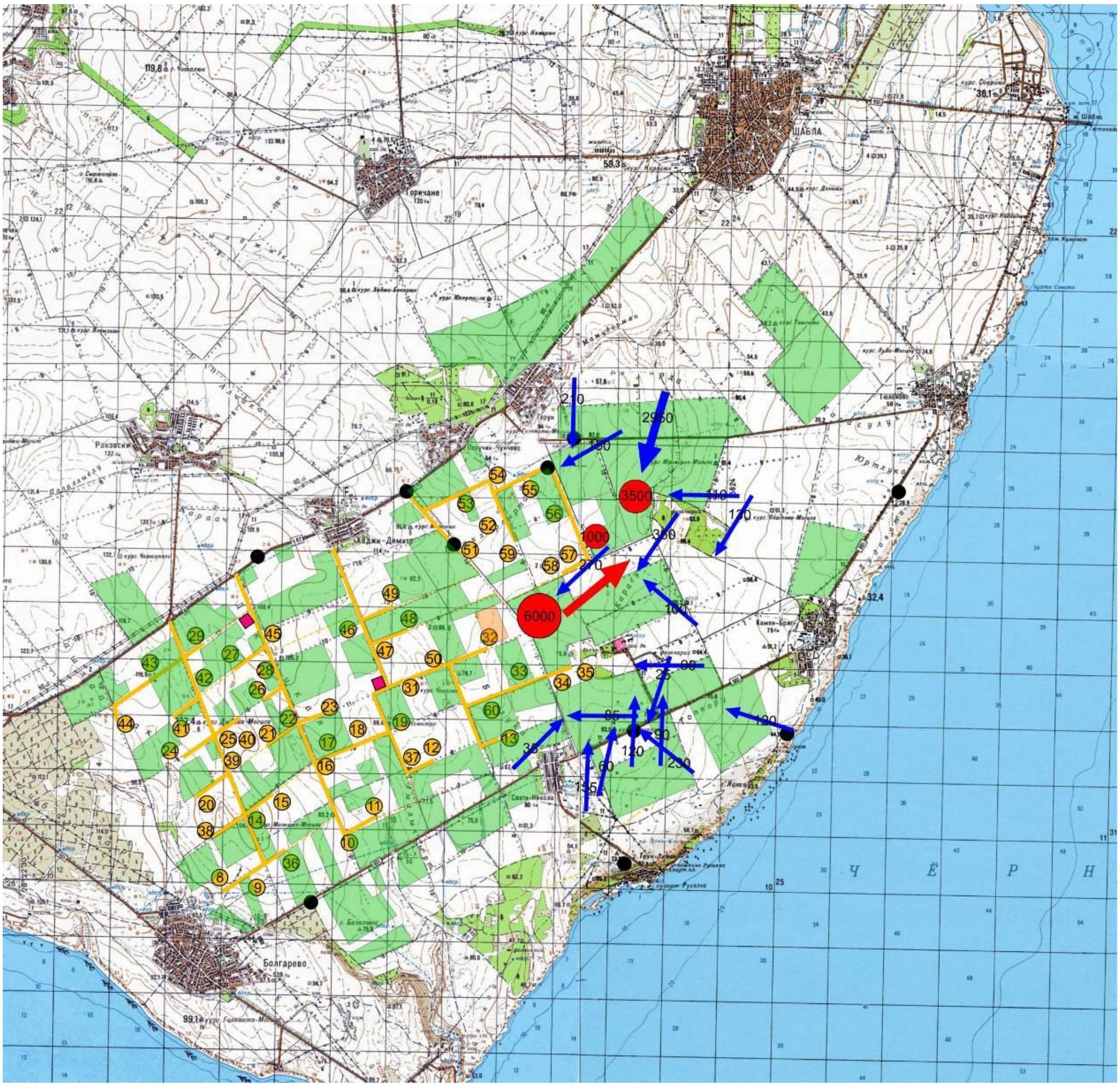
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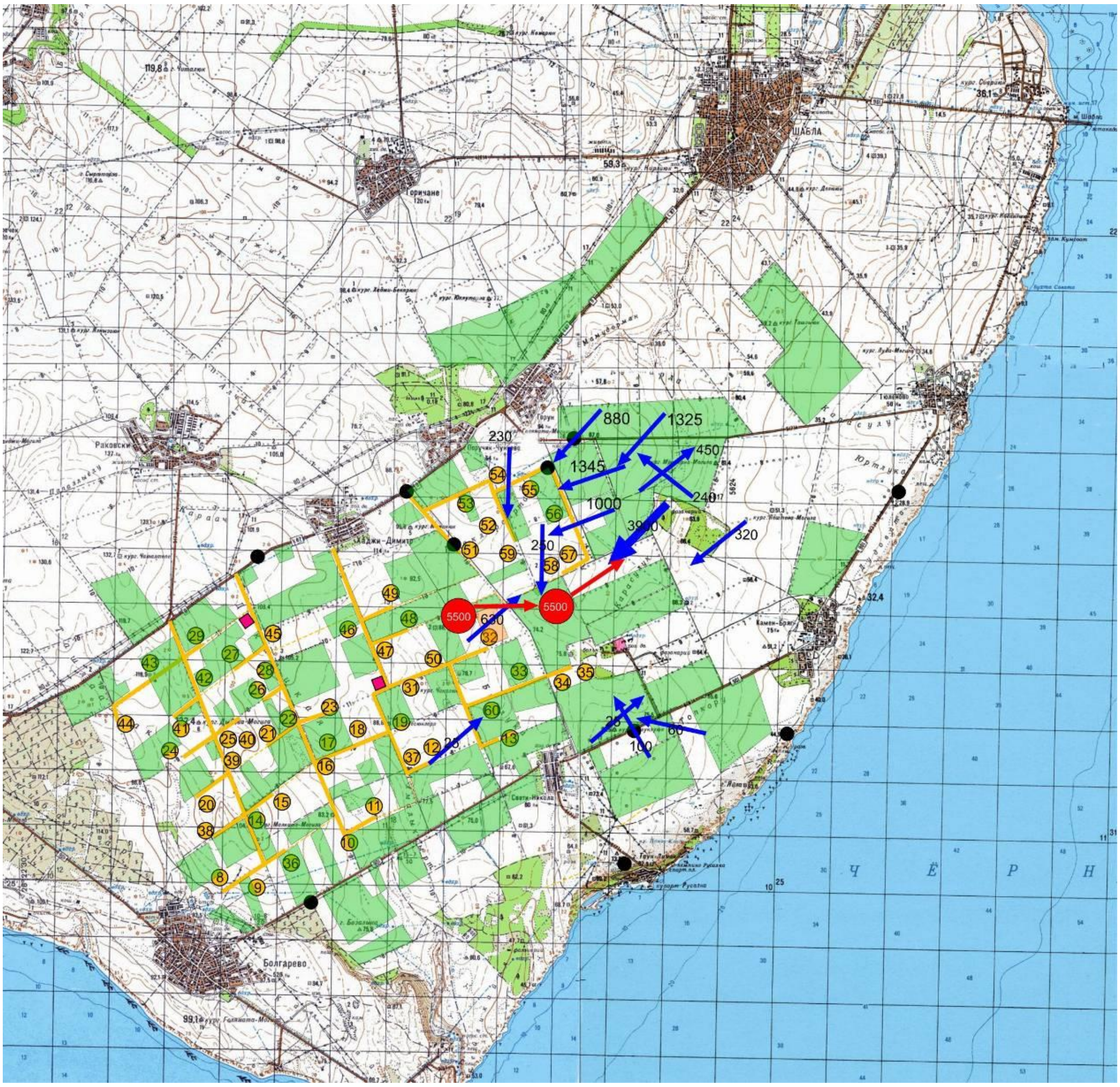
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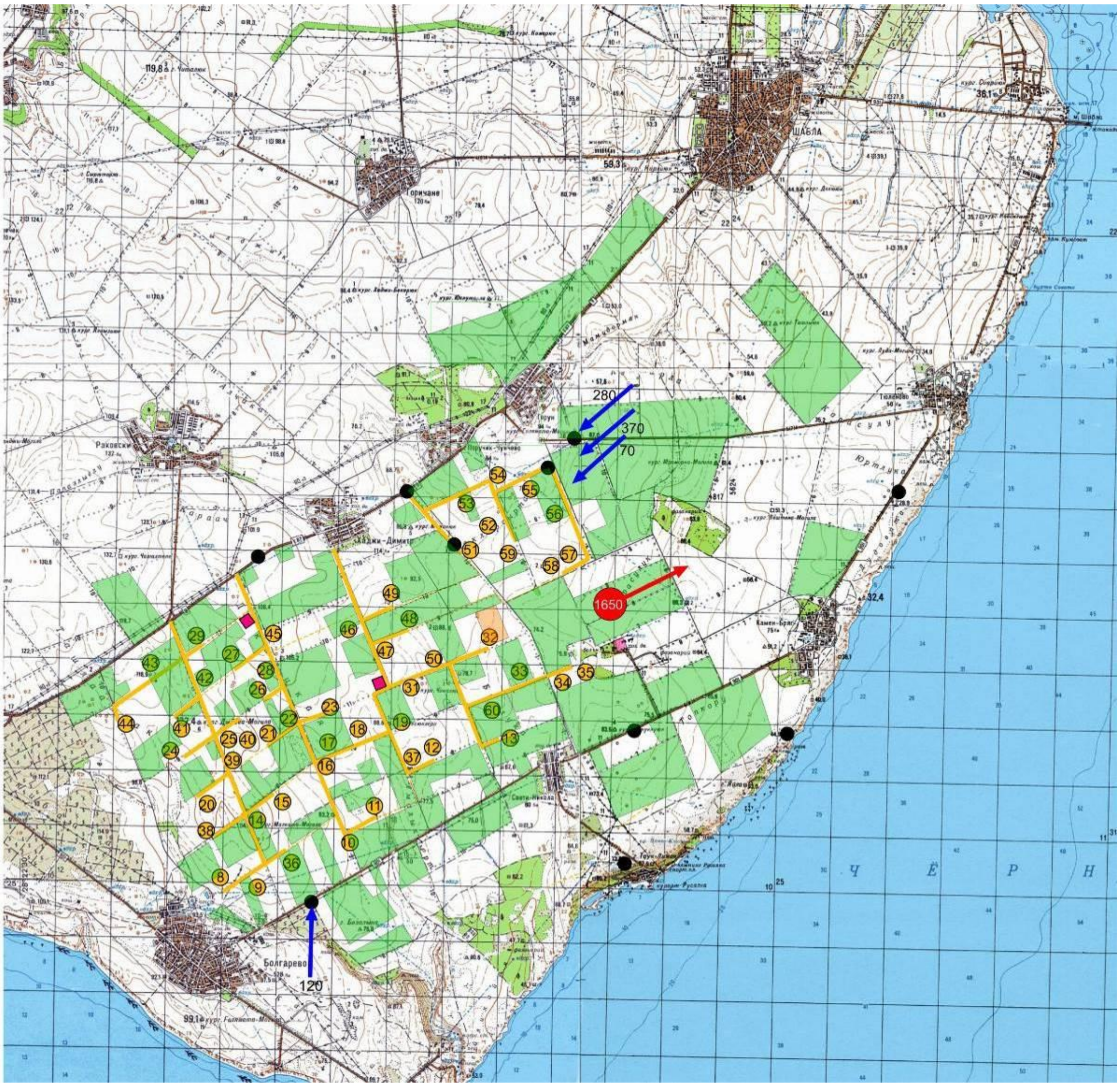
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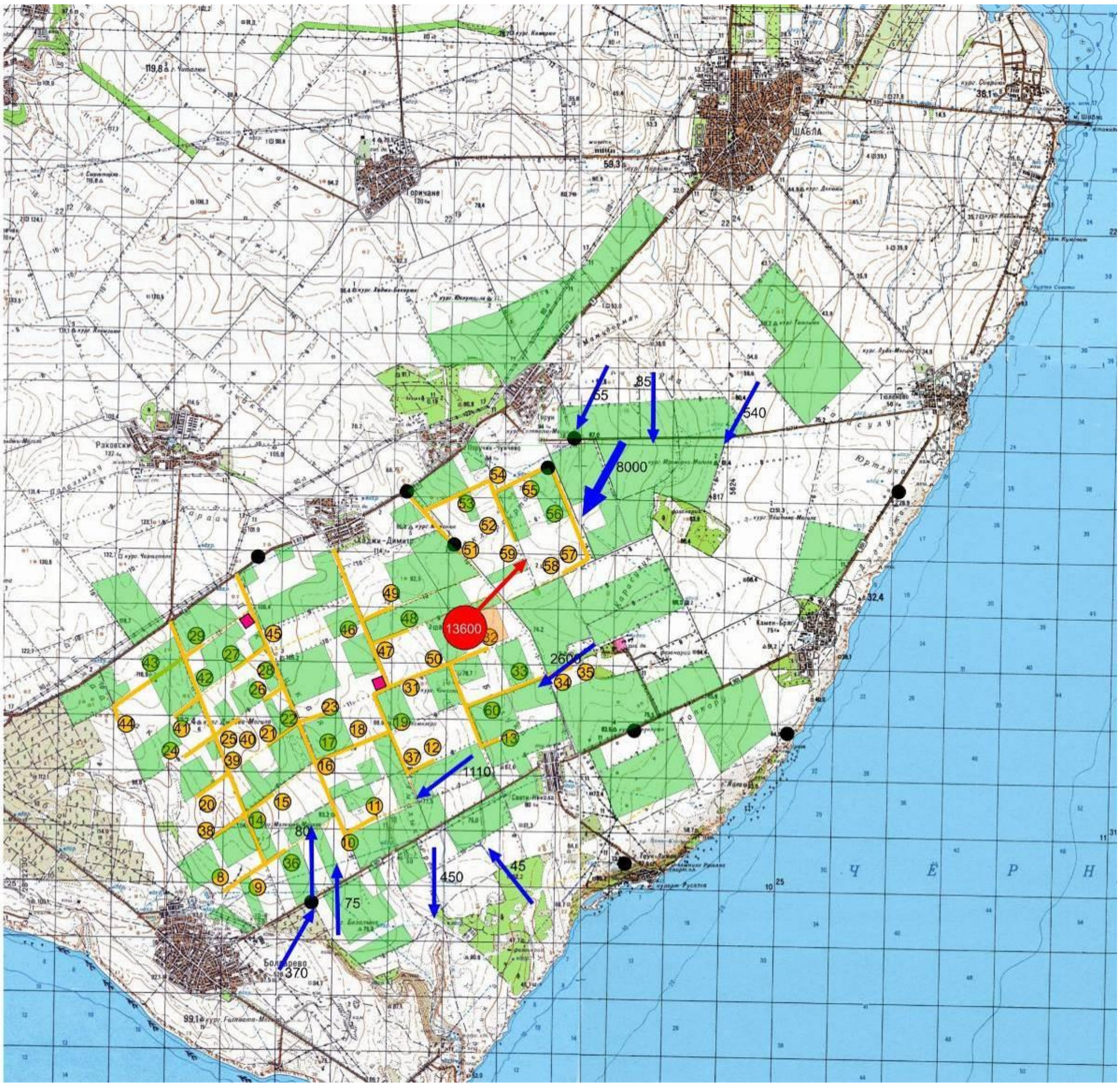

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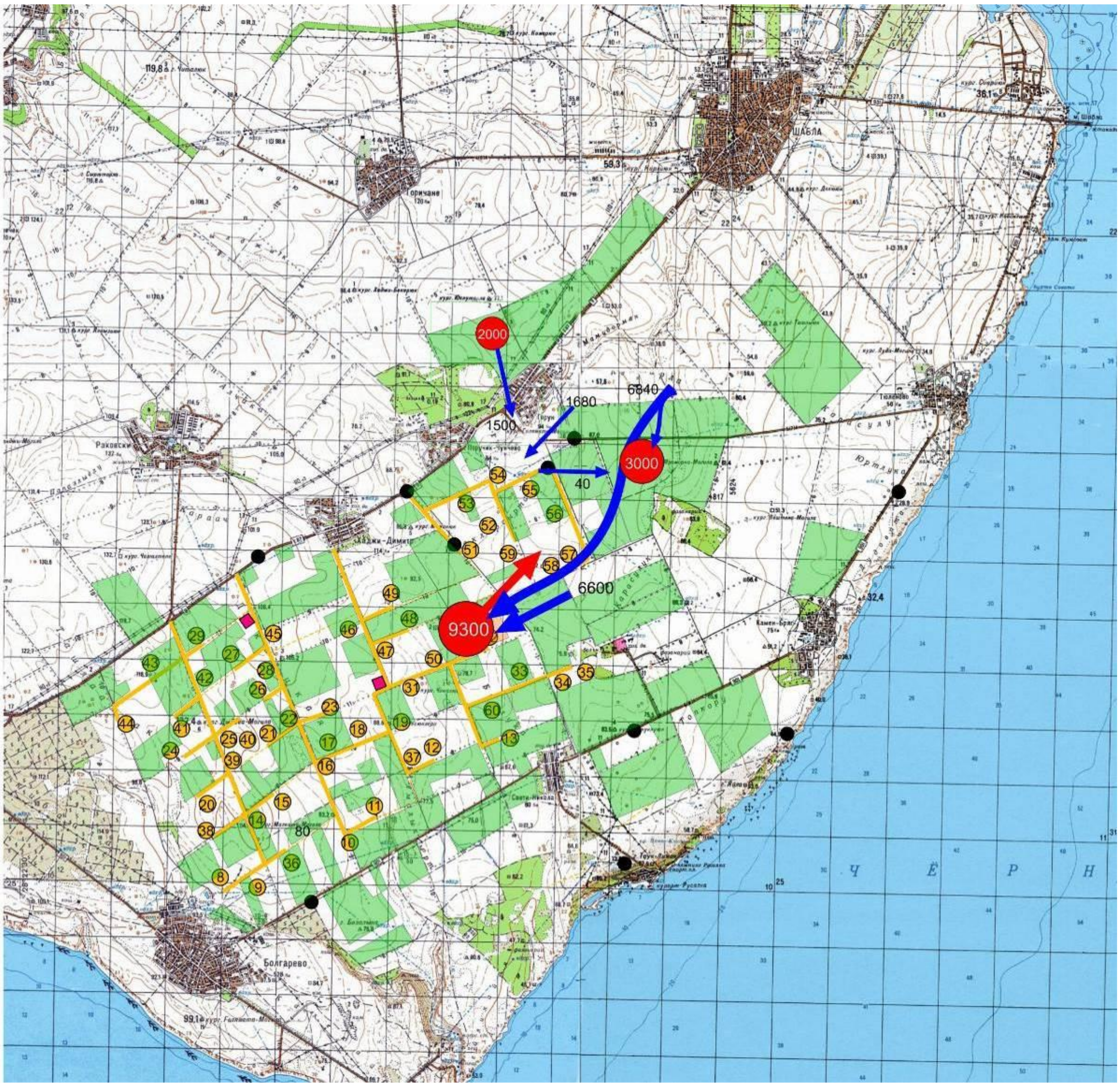

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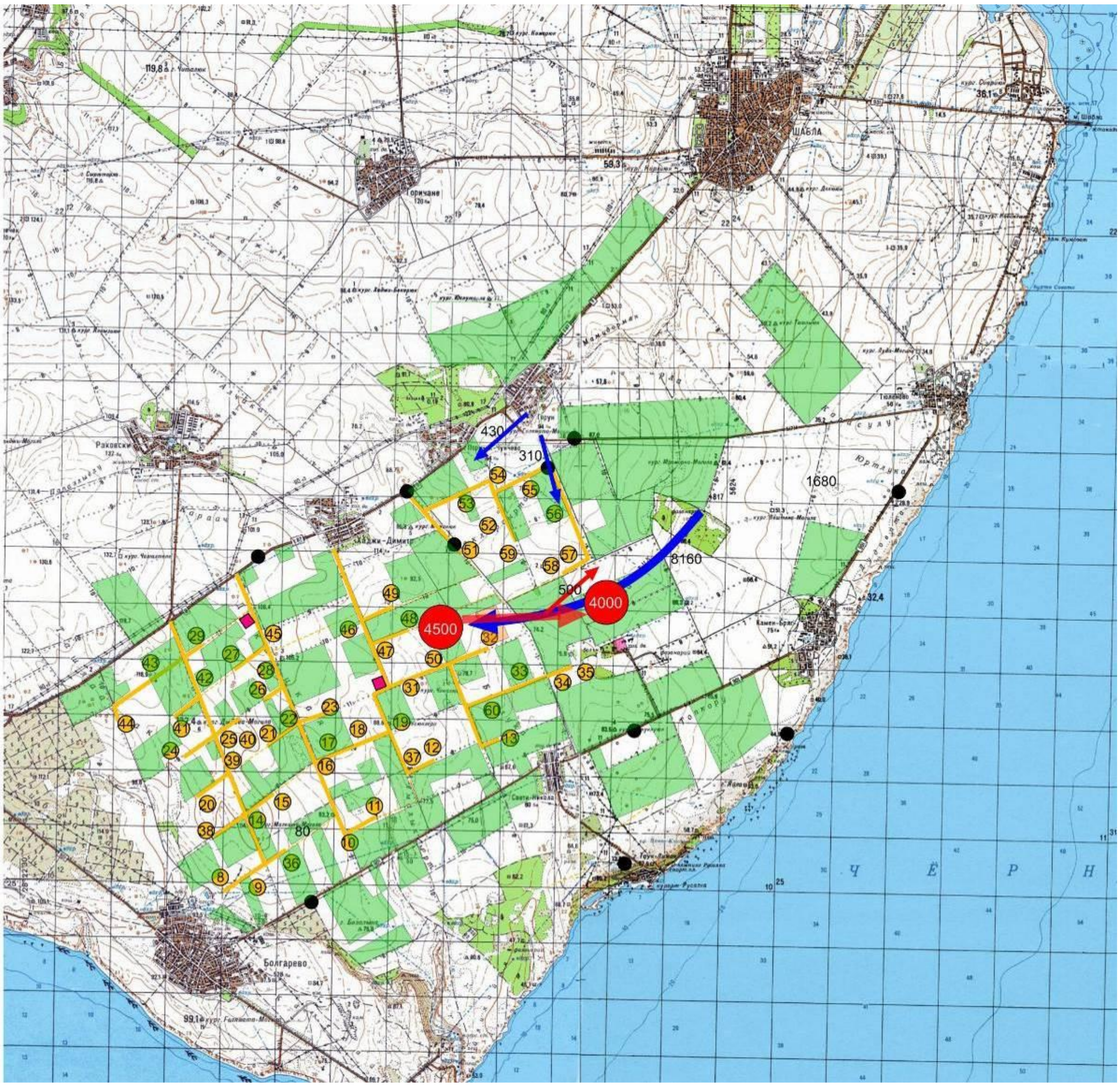

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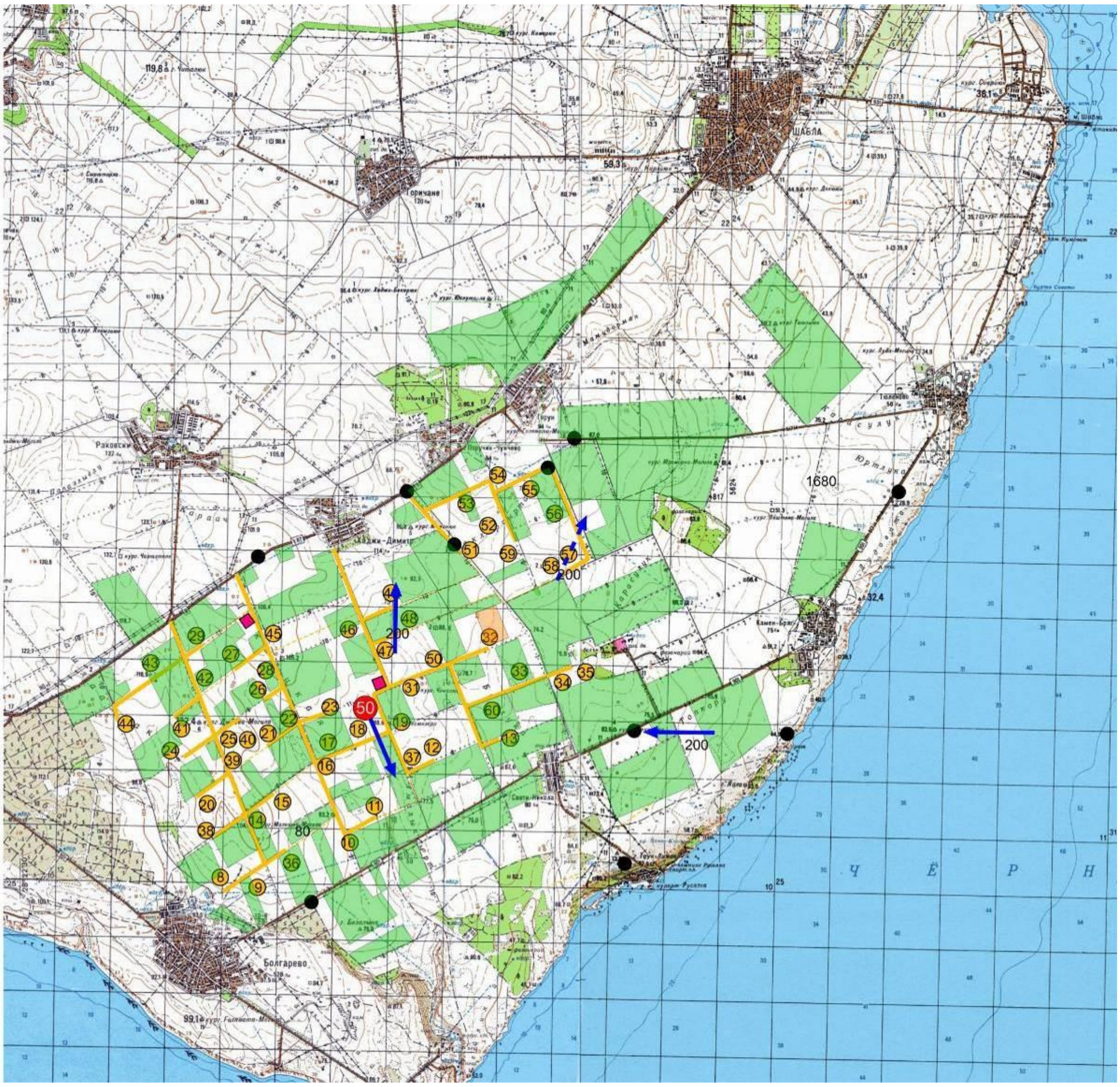

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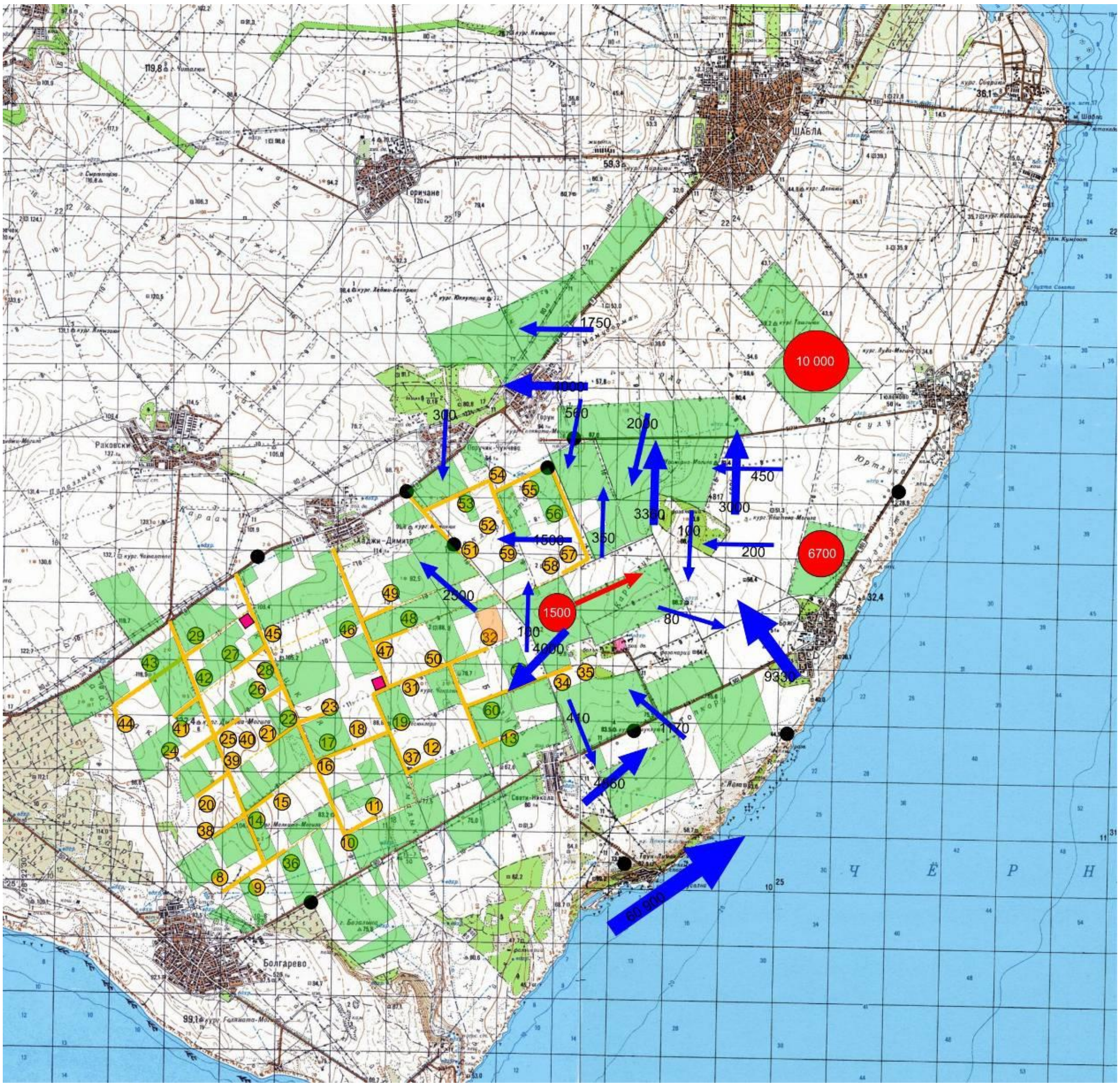
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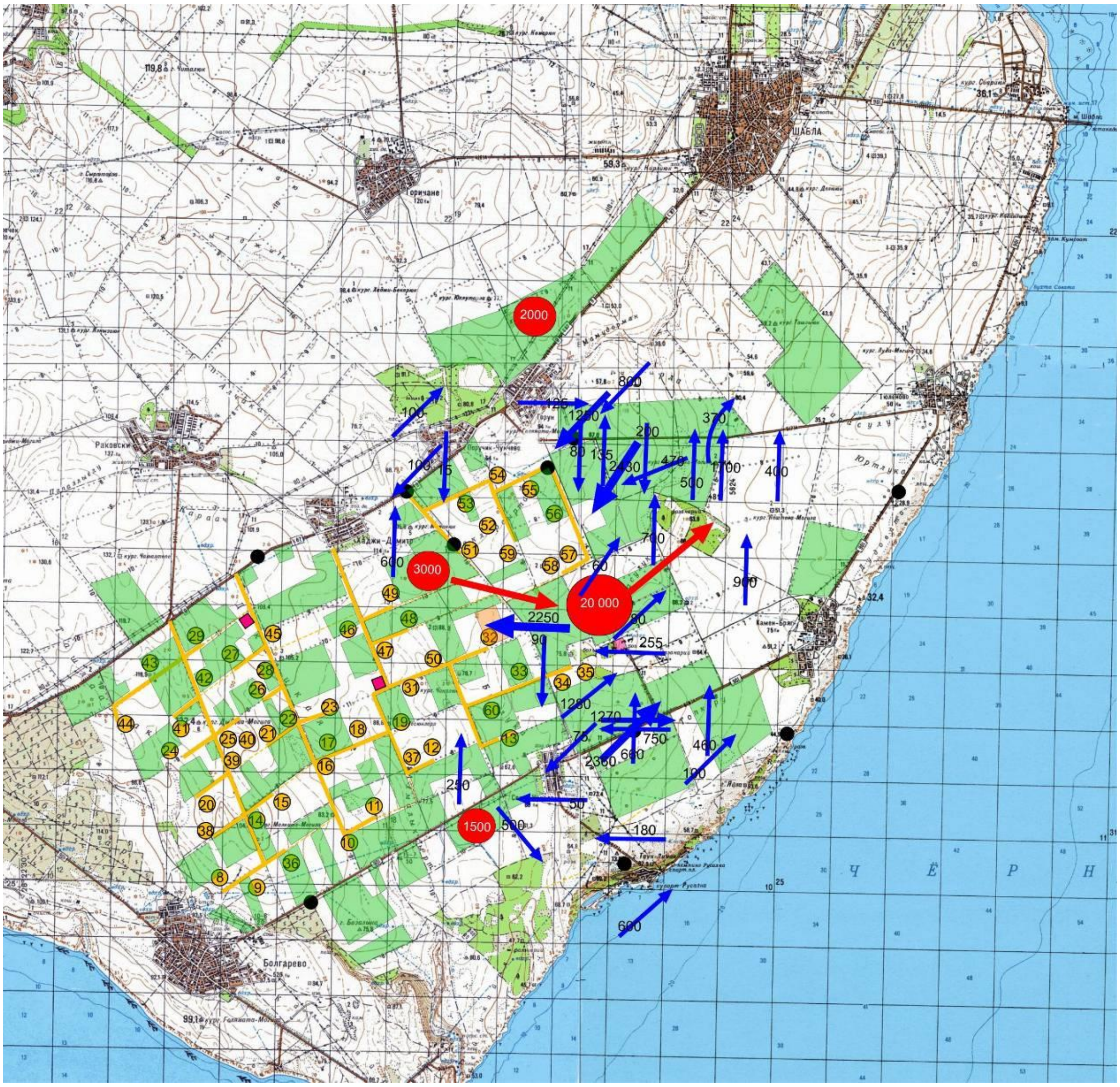
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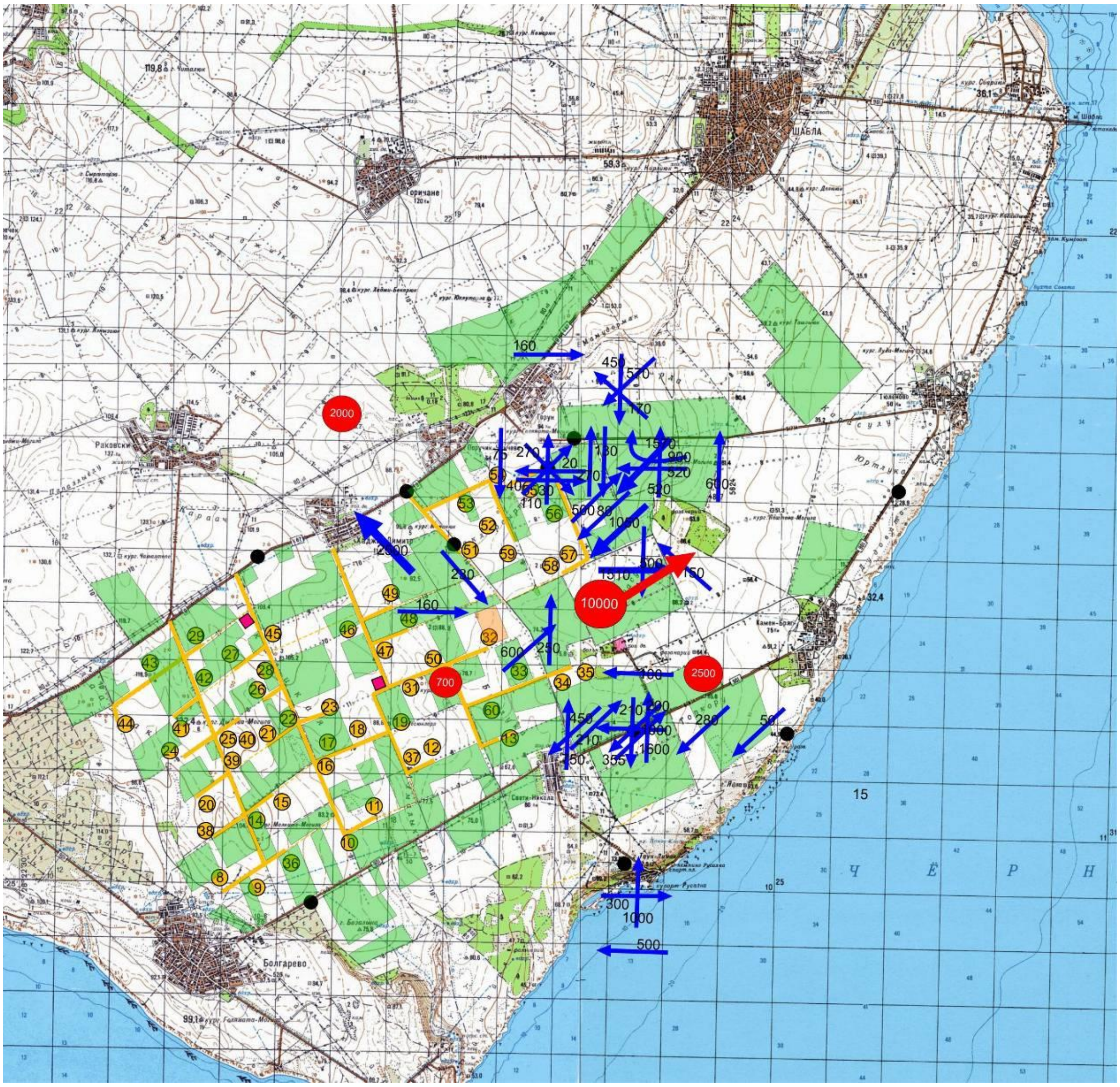
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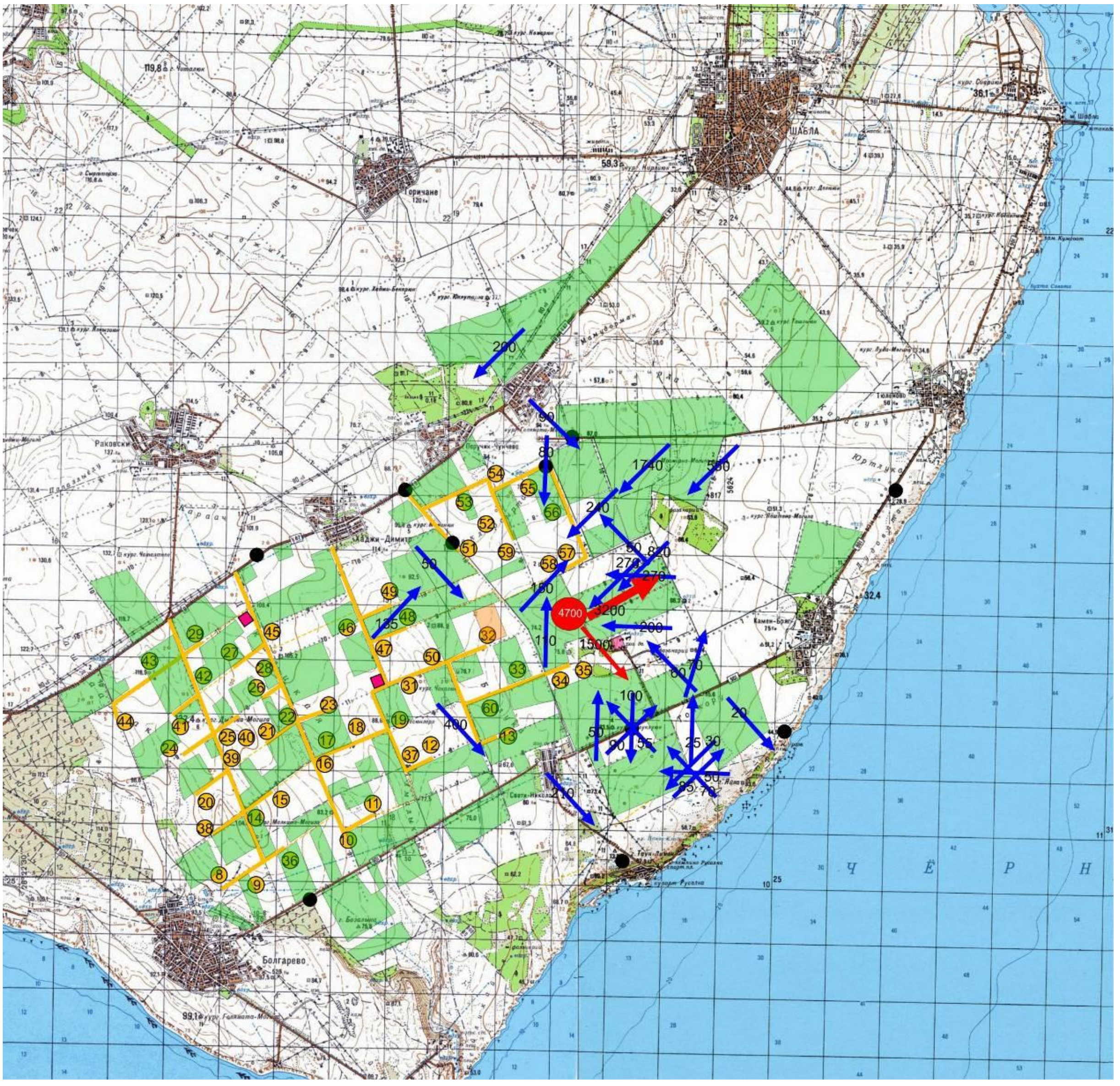

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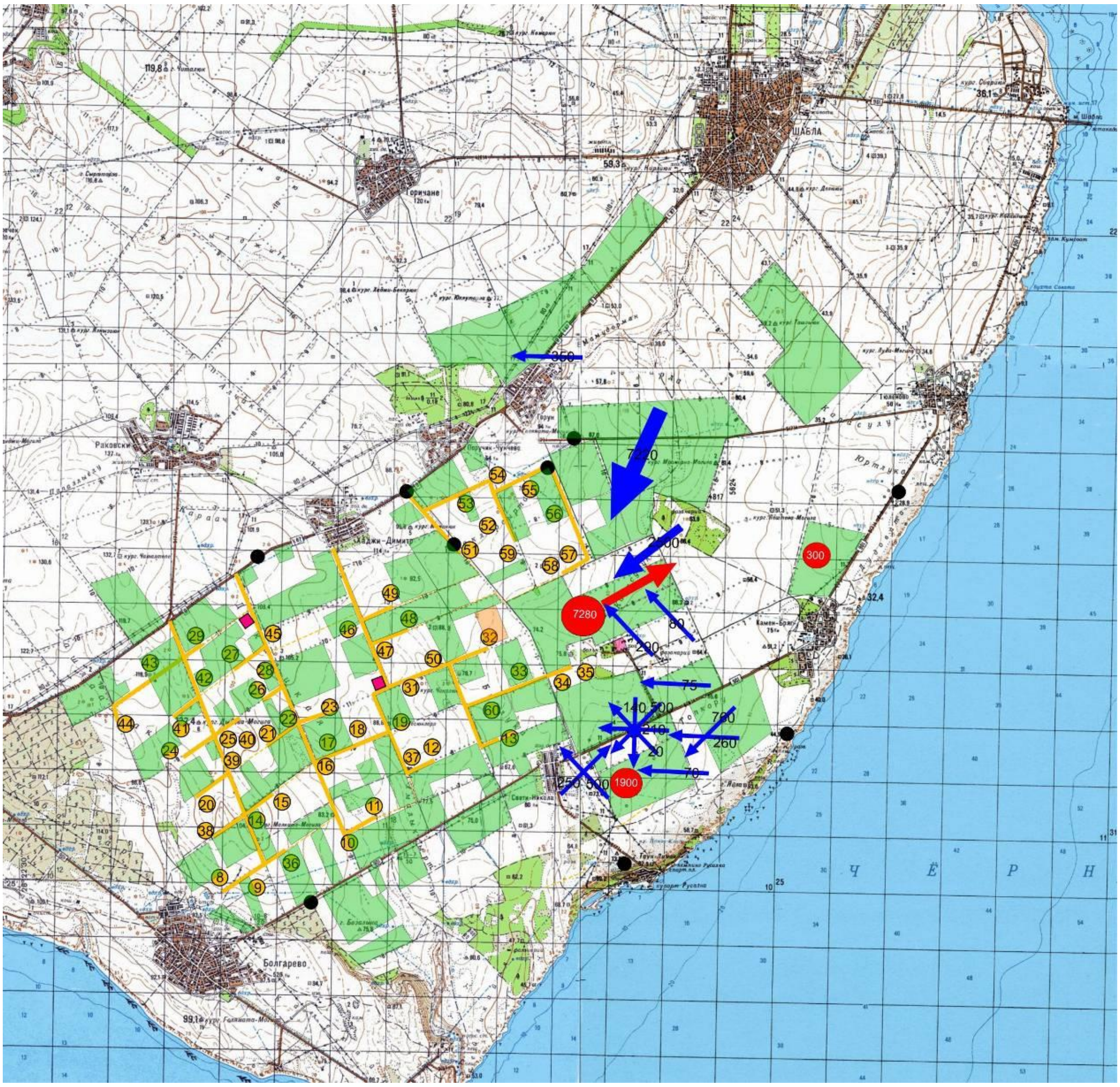

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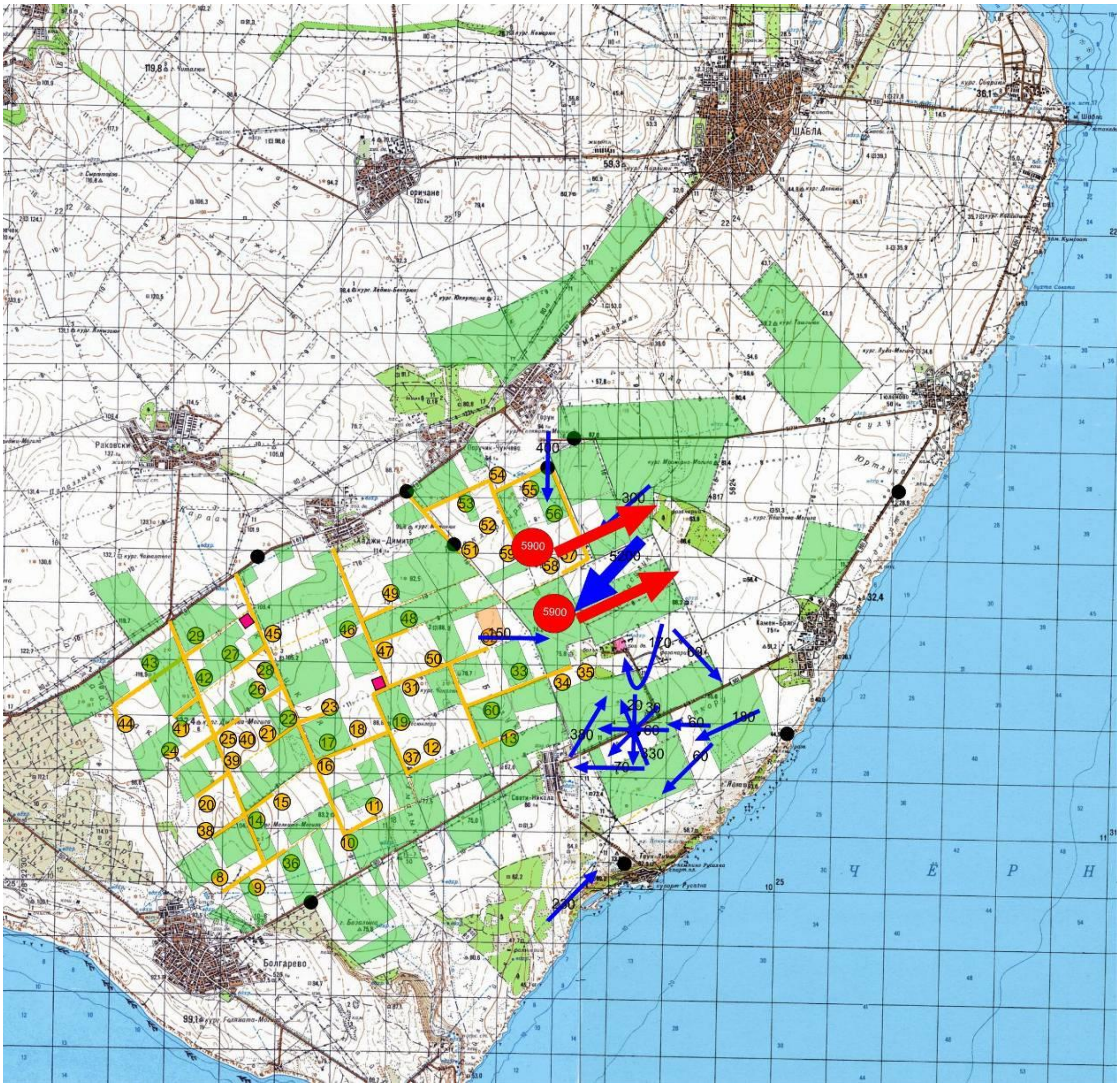

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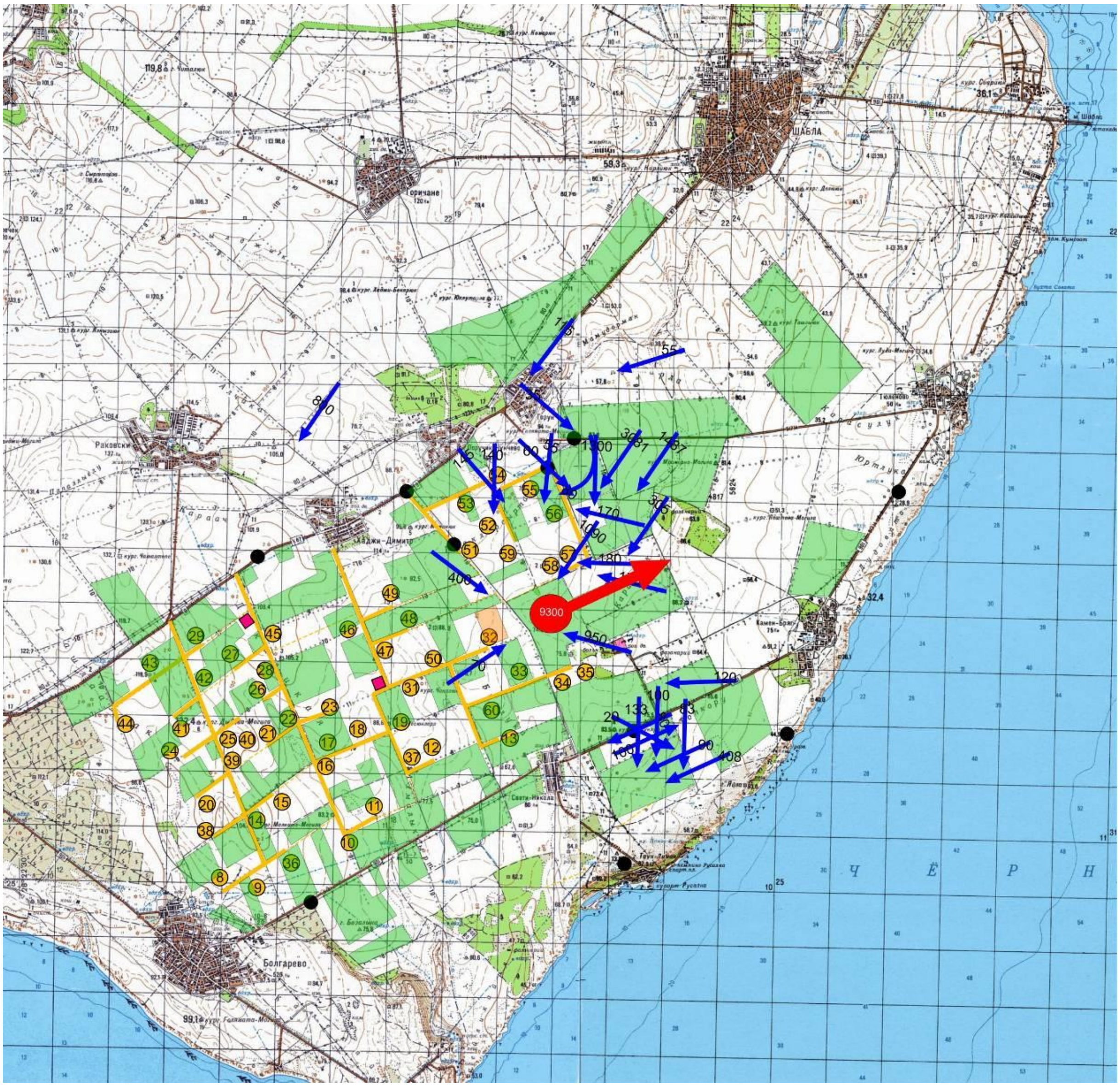

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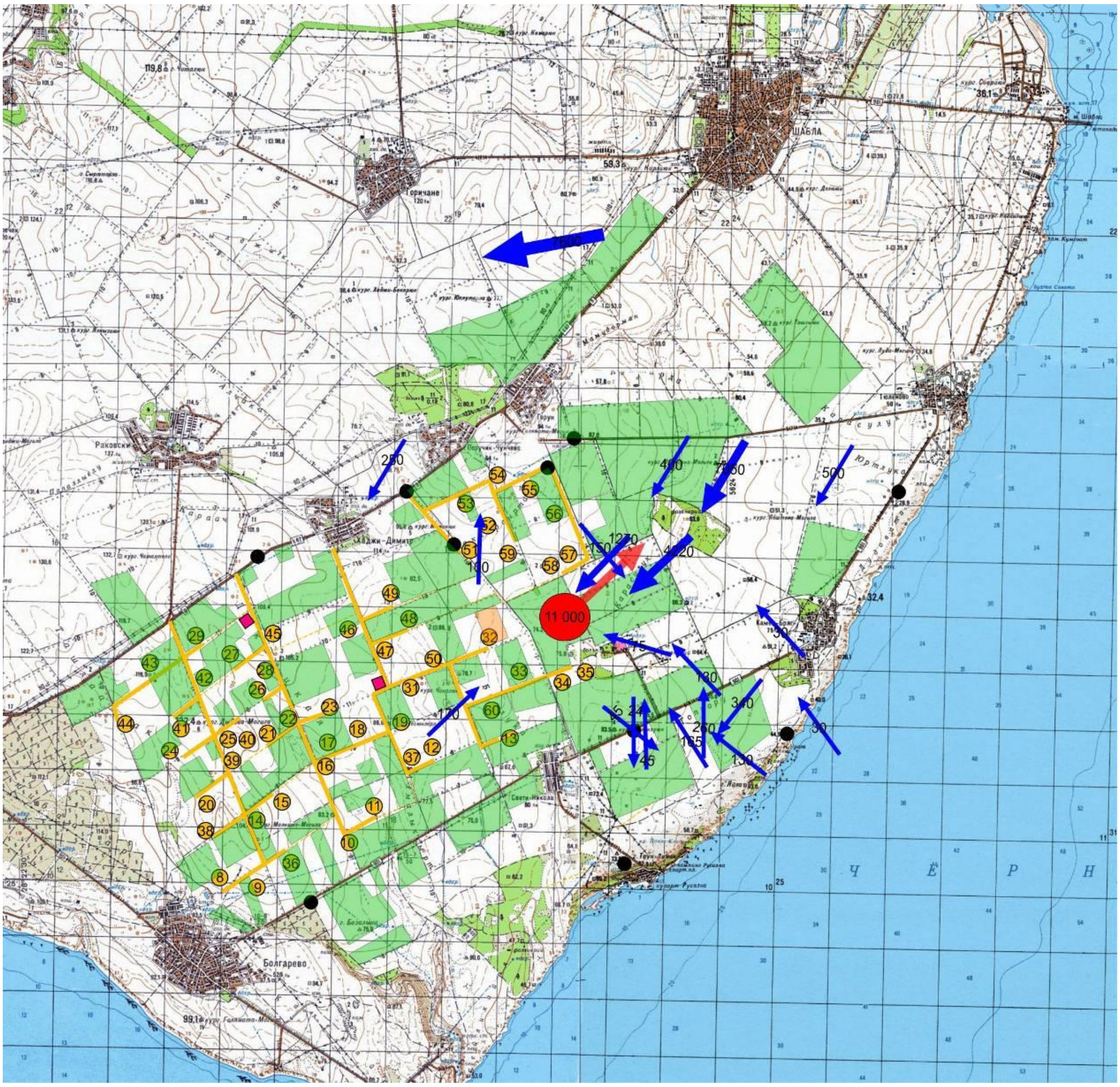

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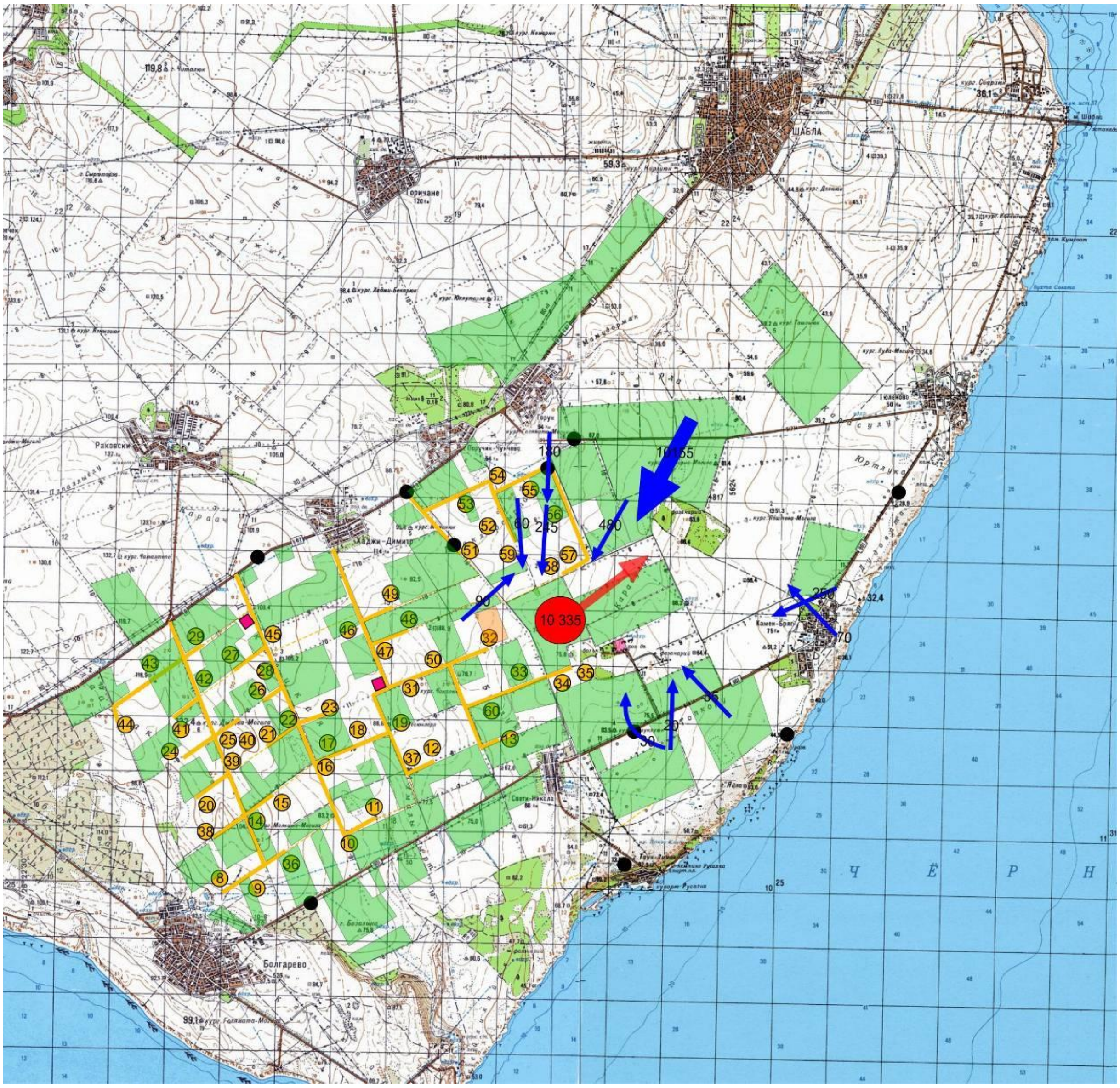

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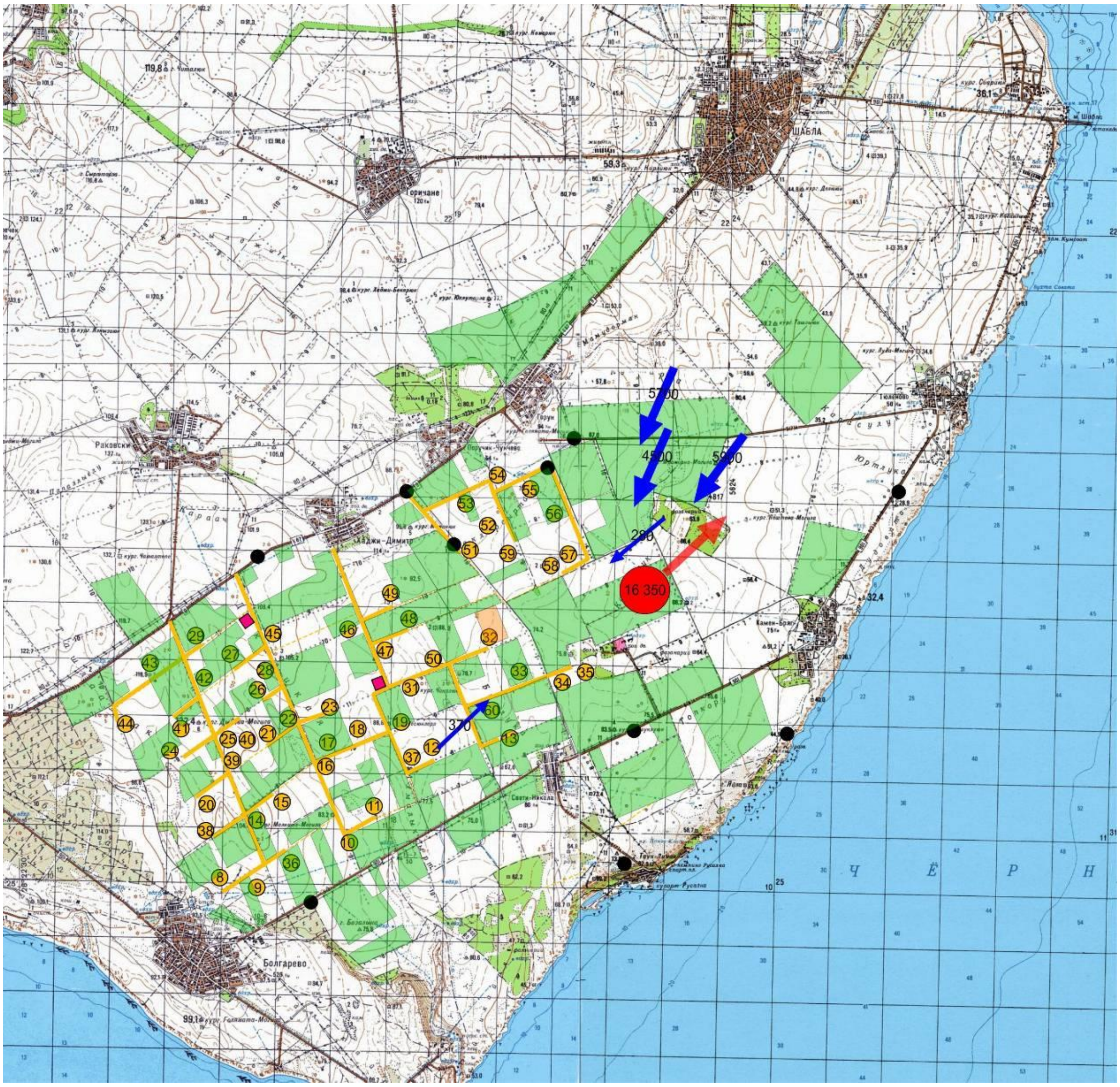

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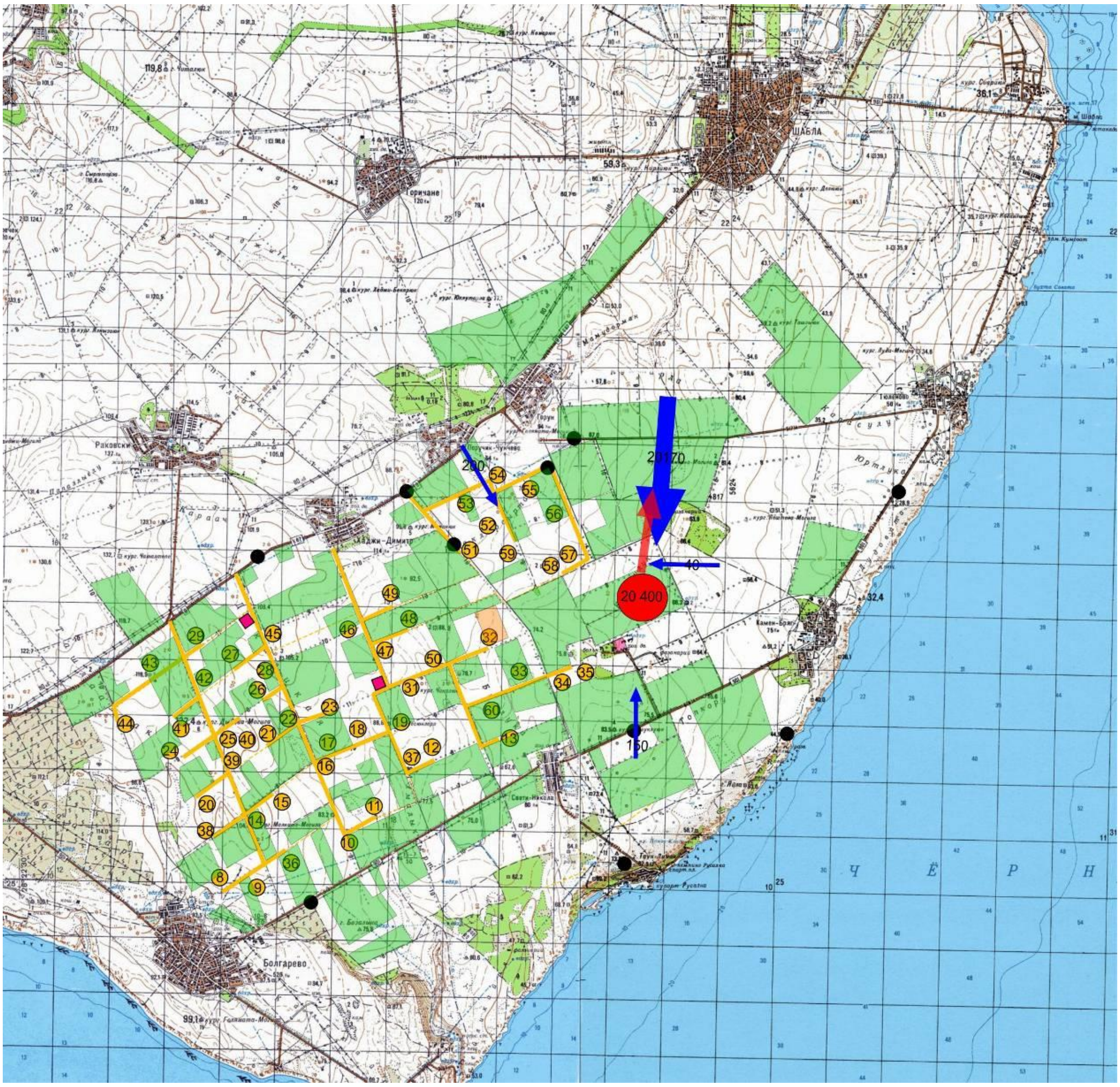

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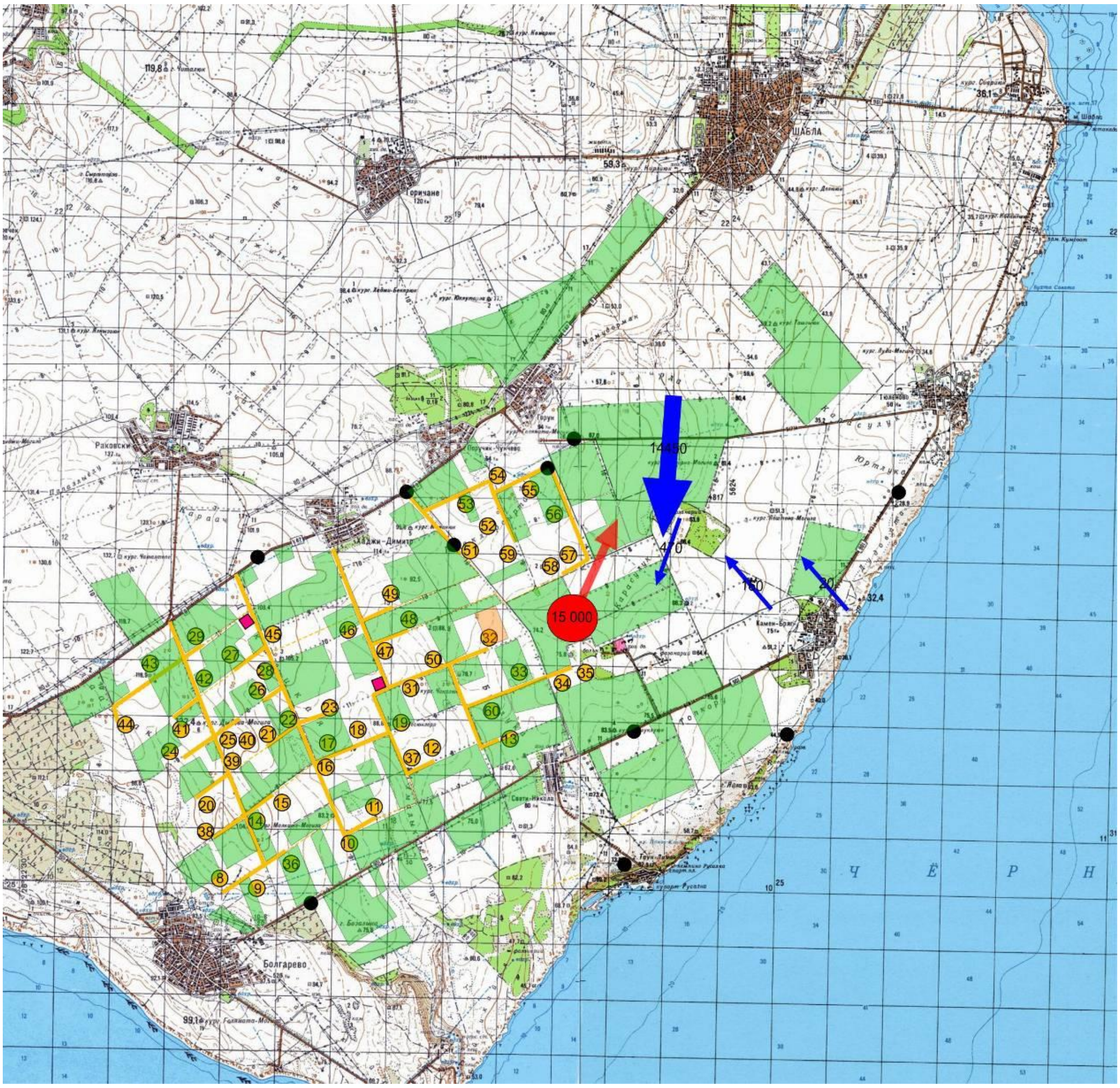
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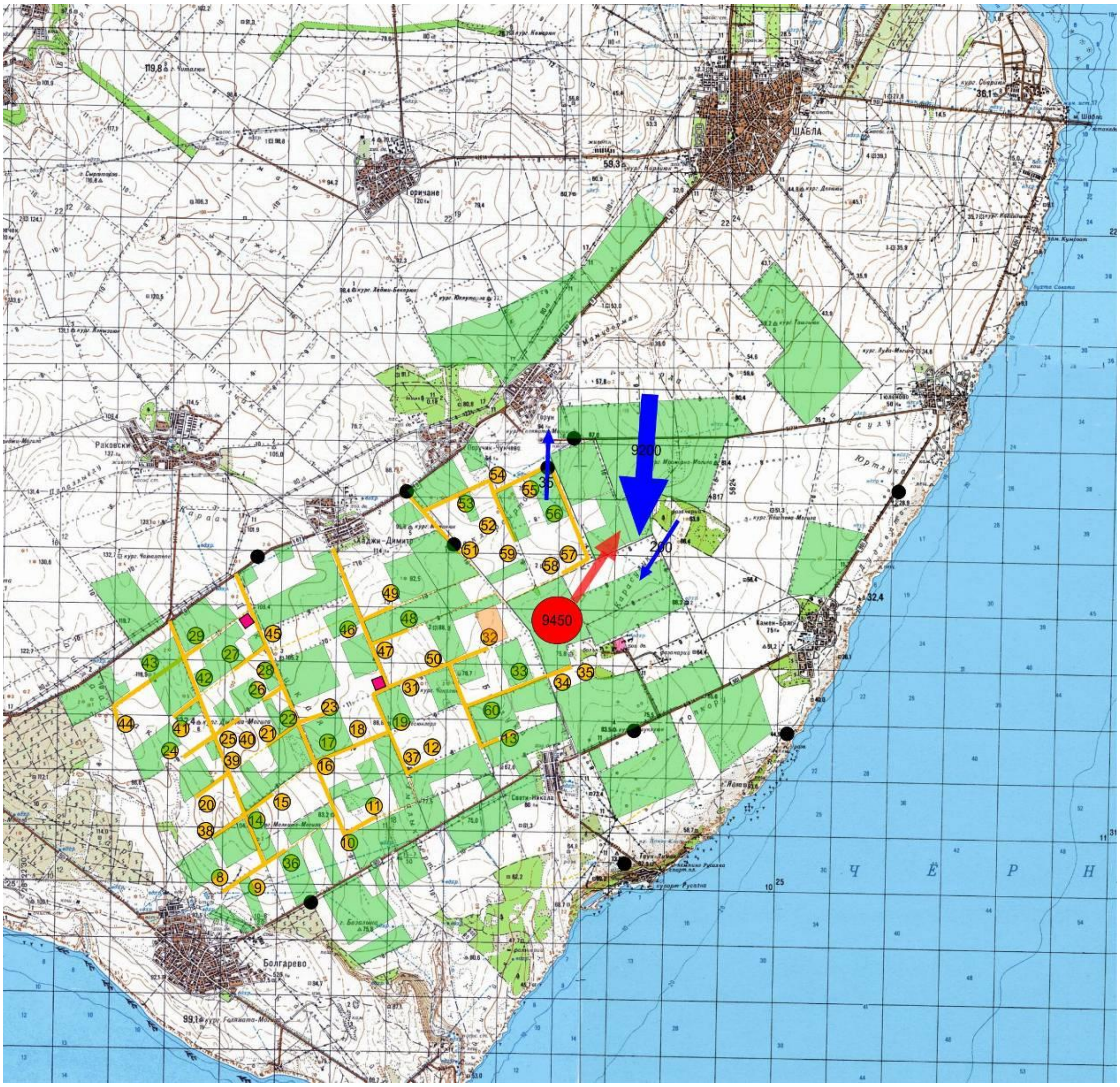

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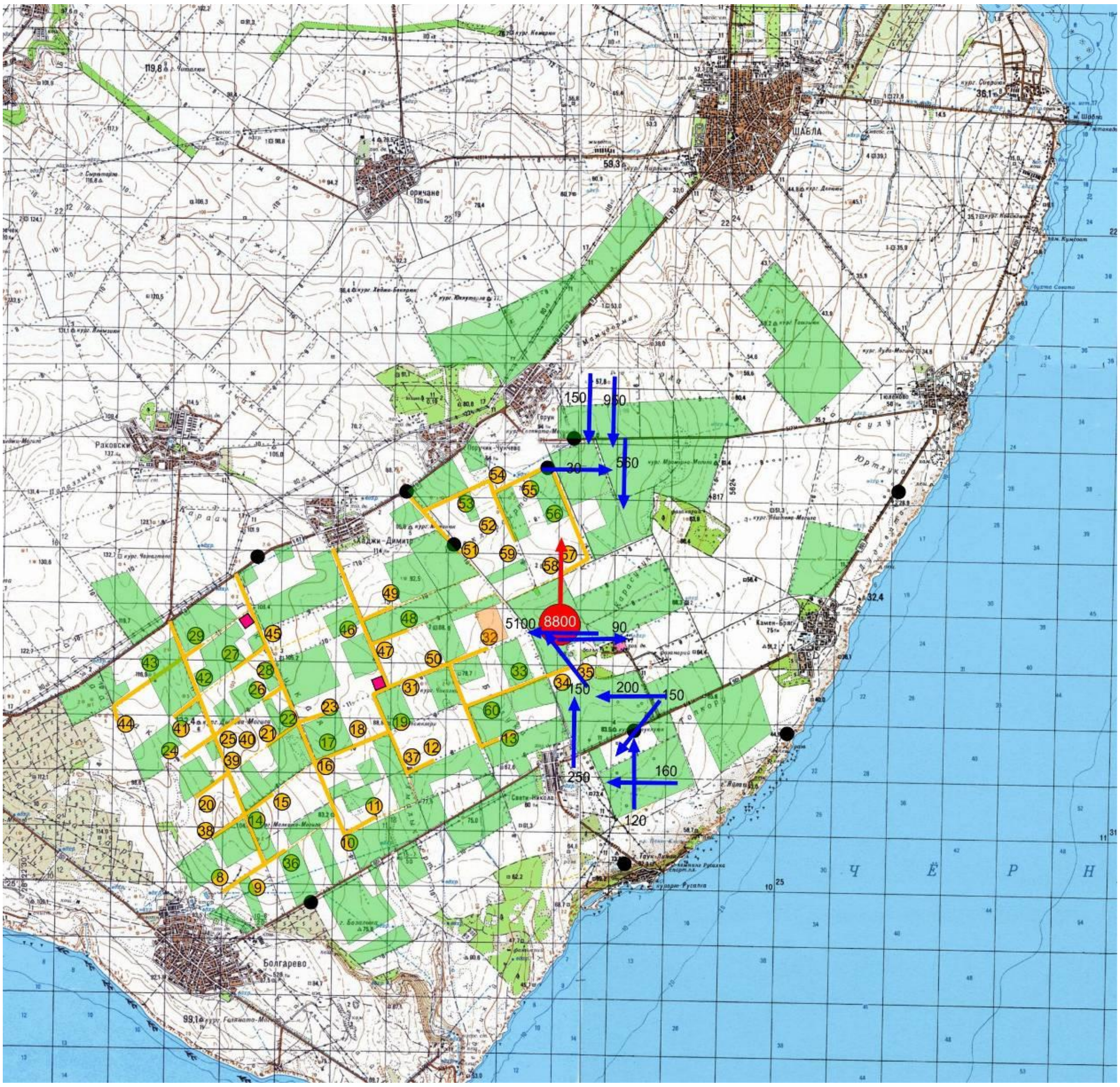
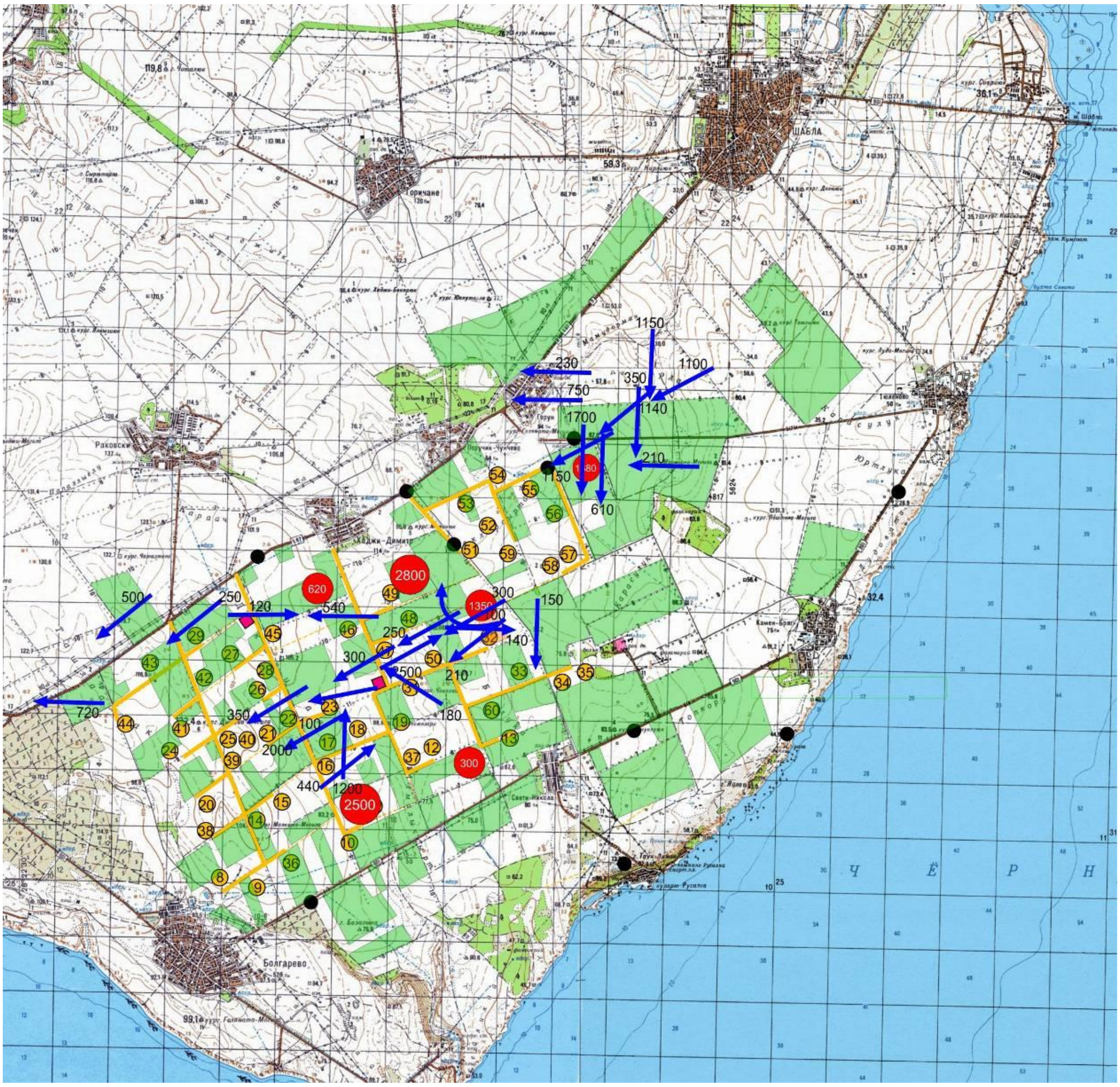
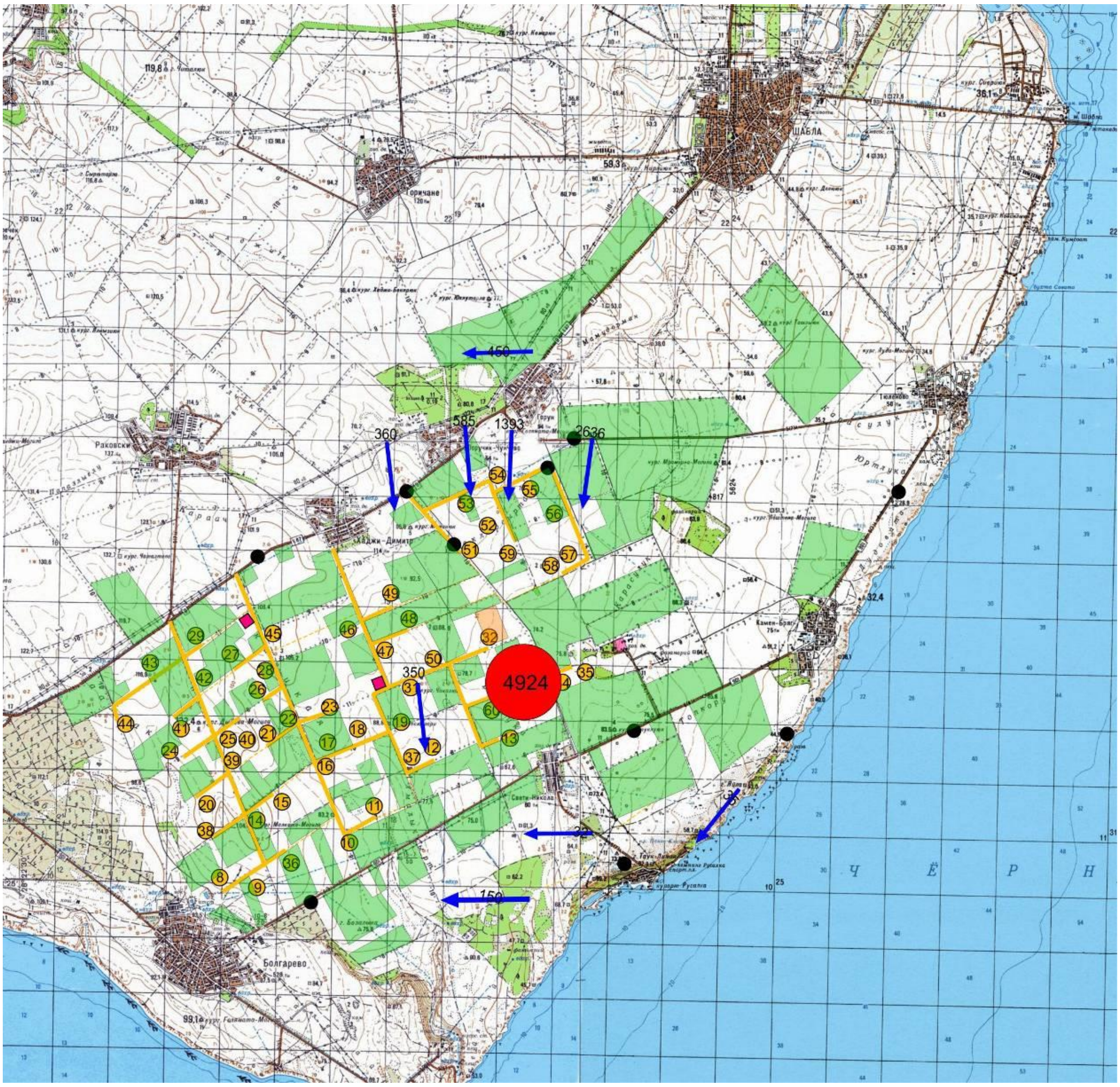


8800
5100
150
950
560
30
90
200
150
250
160
120
Шабла
Горичане
Раковски
Тюленово
Камен-Бряг
Болгарево

26.01.2013



27.01.2013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Шабла
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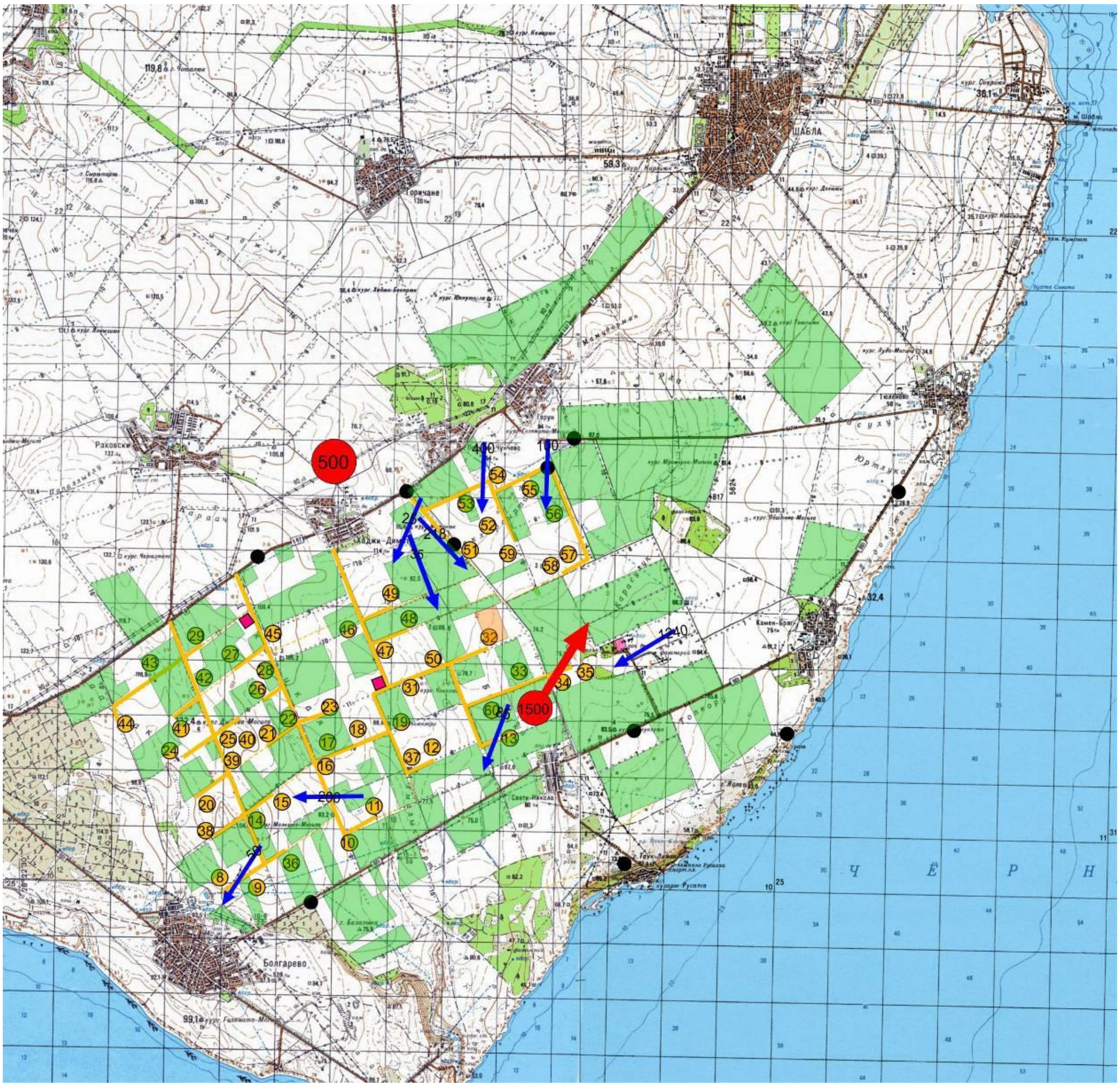
Болграево

28.01.2013



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Раковски
Тюленово
Болгарево
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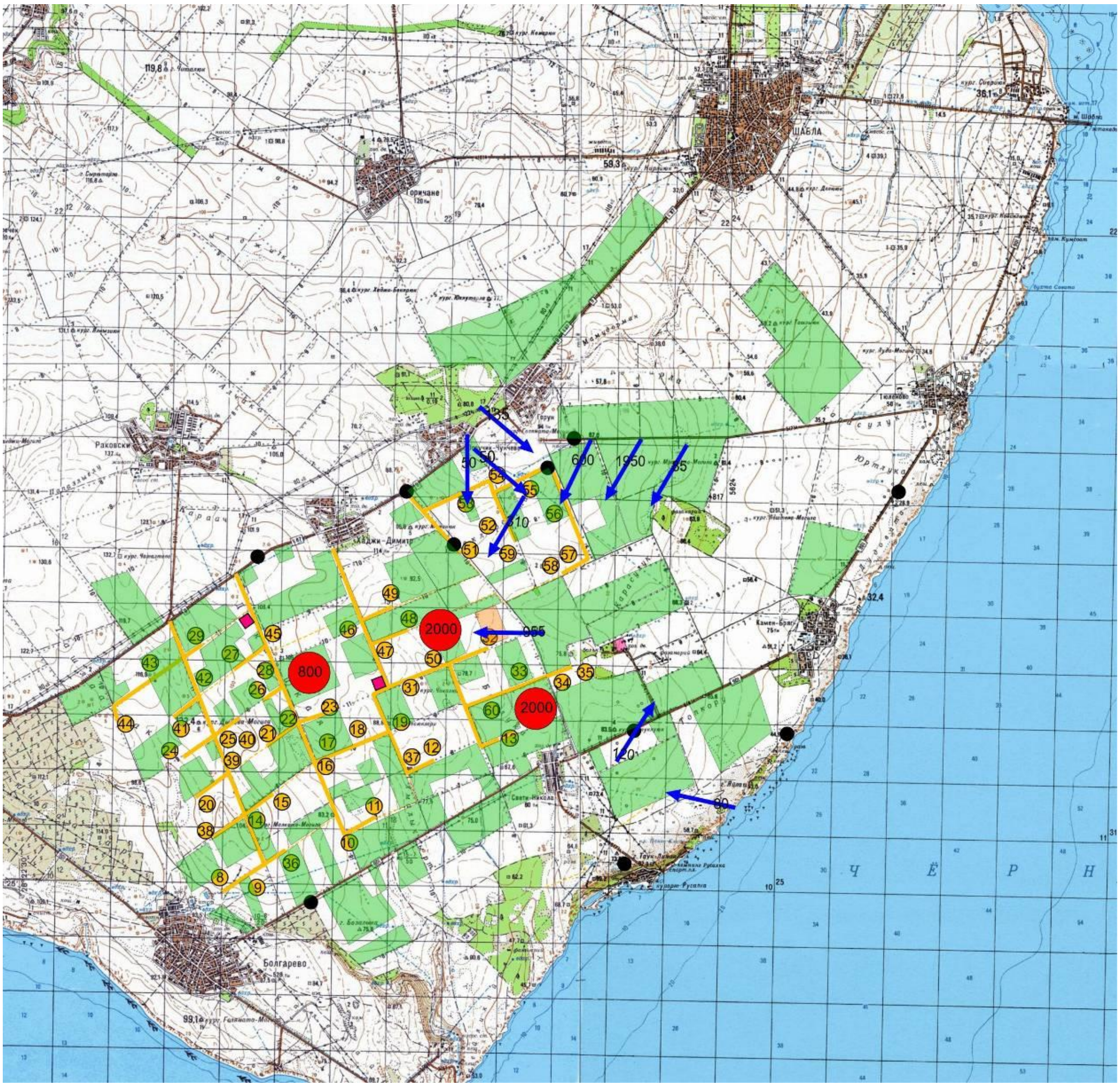
29.012013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Горичане
Болгарево
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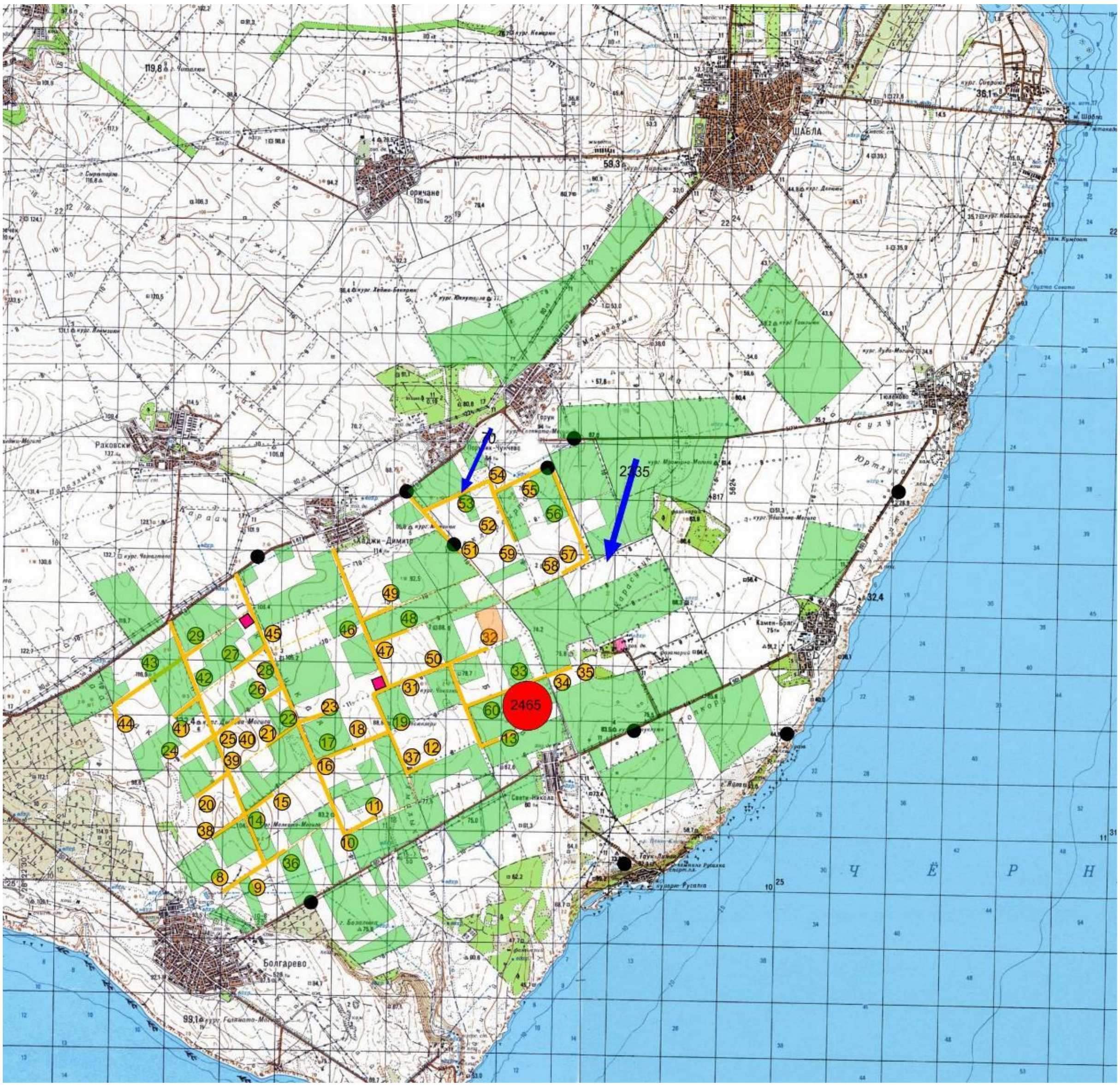
30.01.2013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Болгарево
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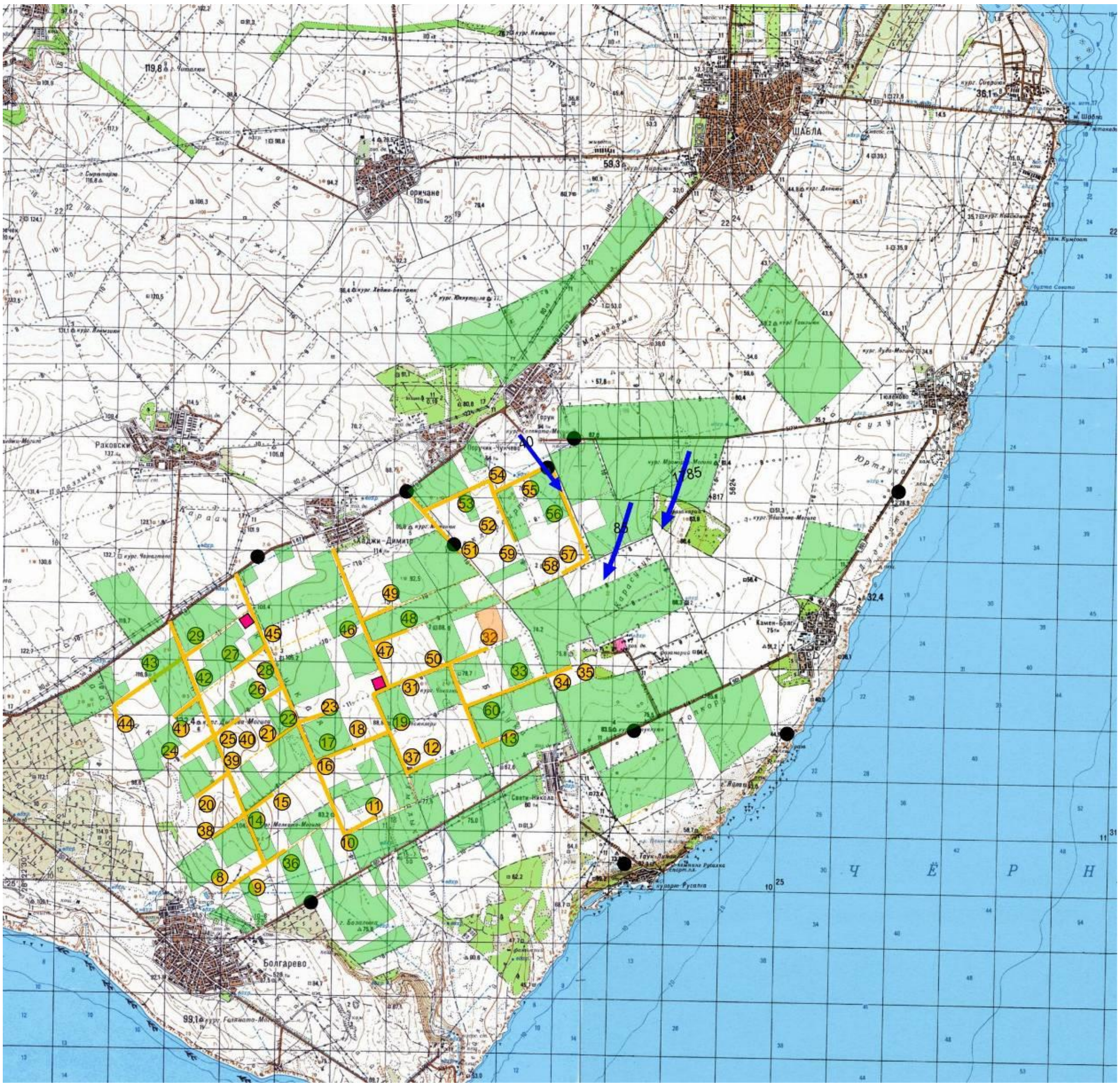
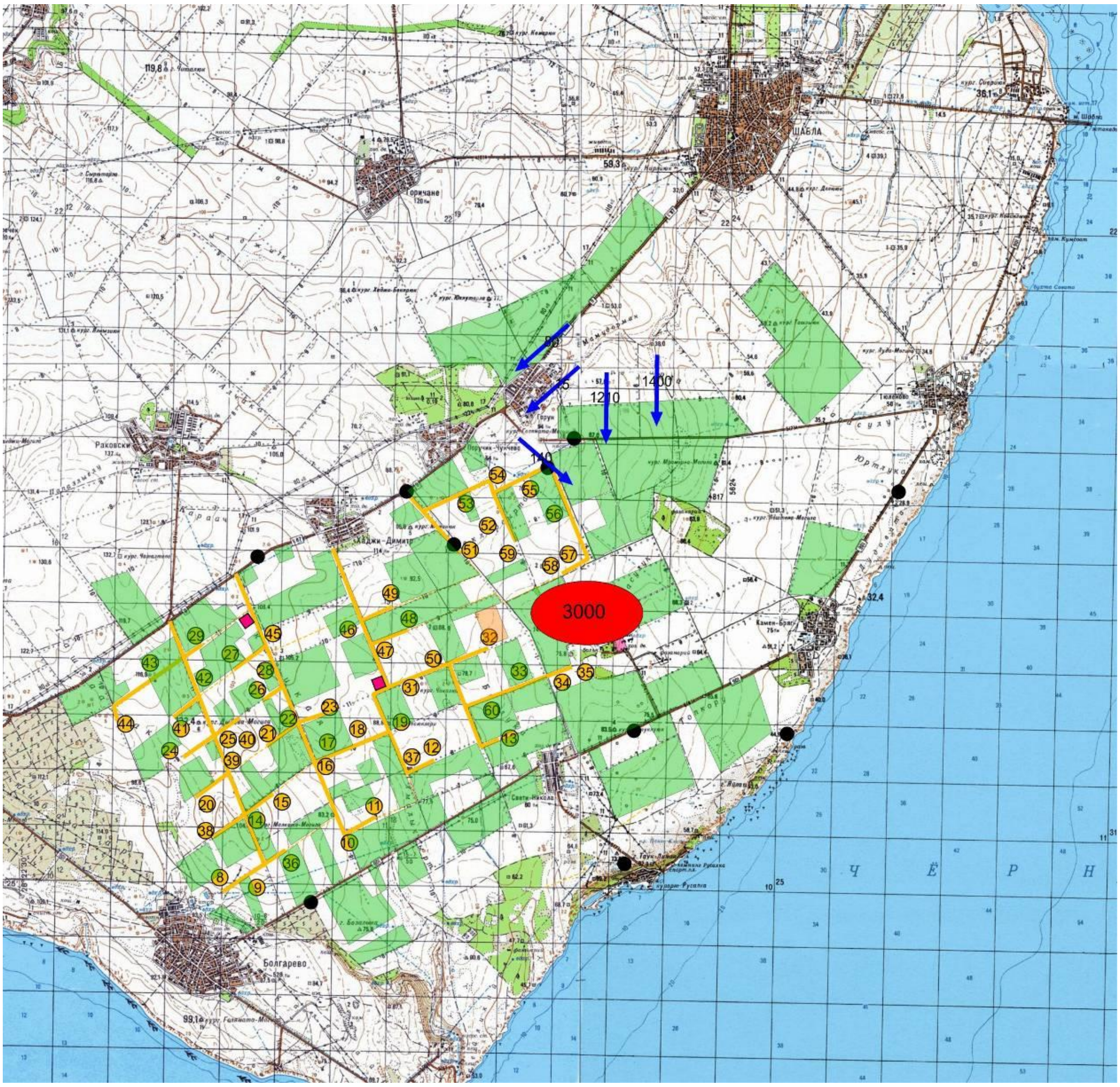
Ч Е Р Н

31.01.2013



01.02.2013



Шабла
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Раковски
Тюленово
Каменя-Бряг
Болгарево
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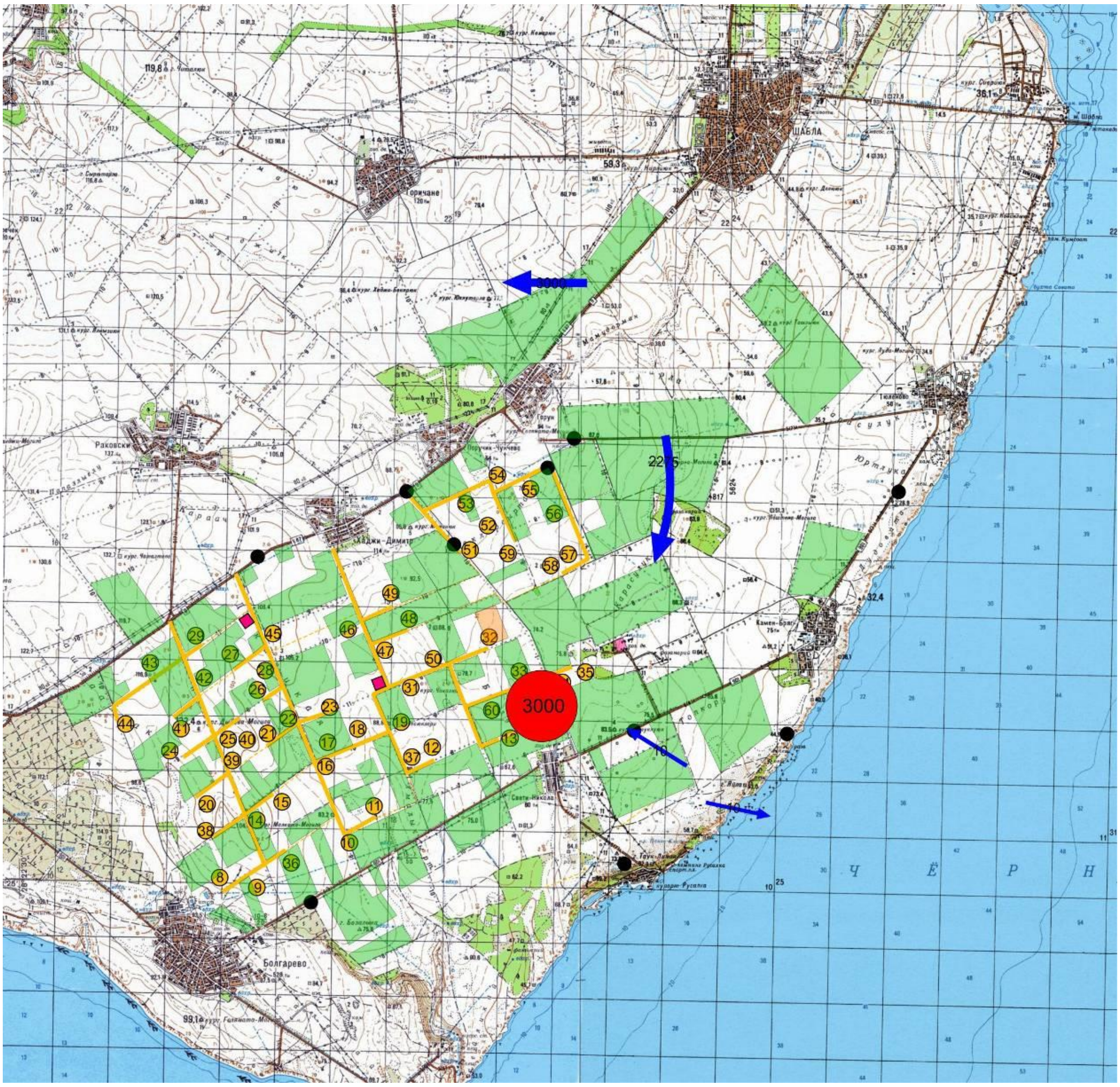
140

02.02.2013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2275
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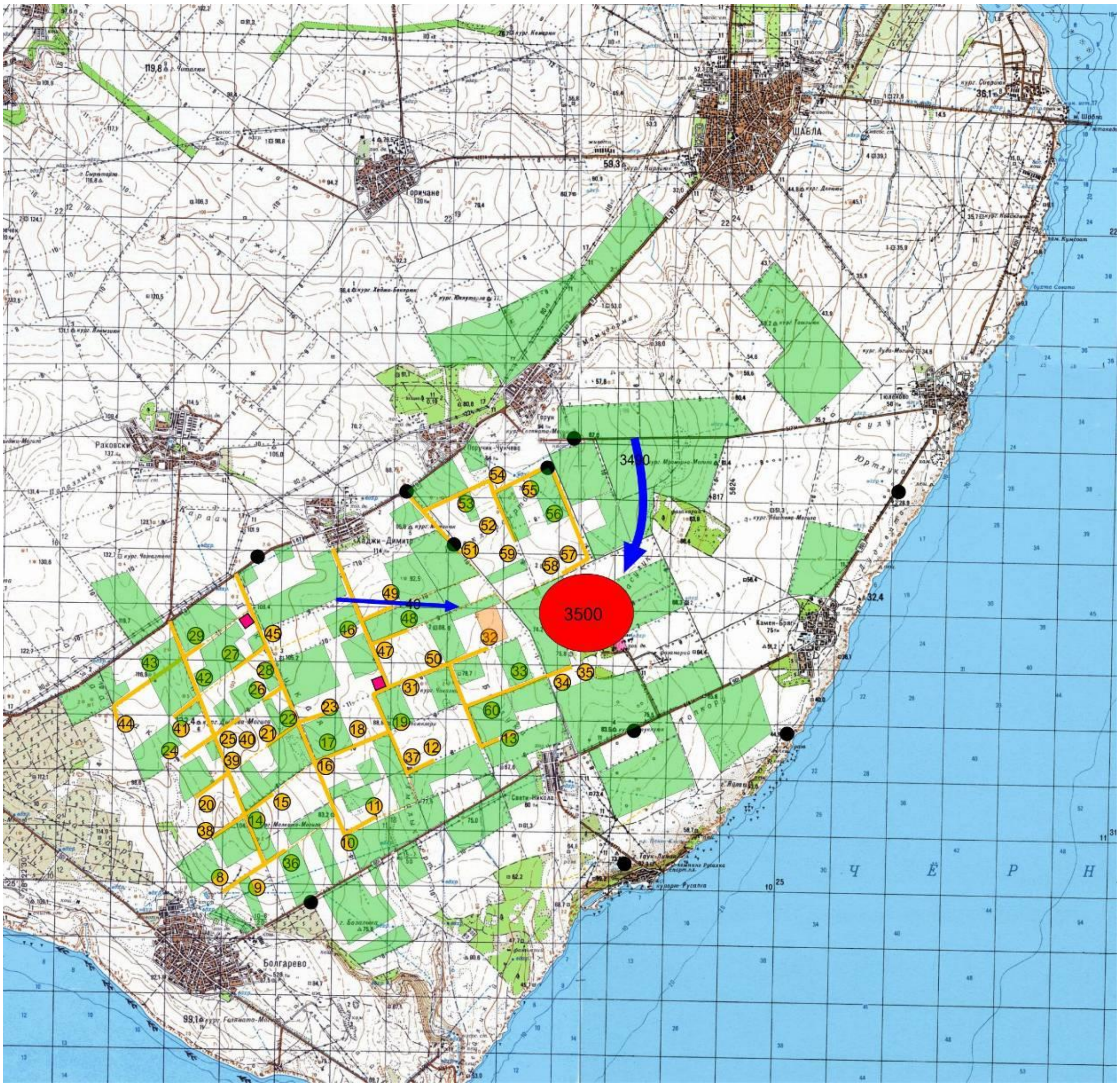
Шабла
Горичане
Тюленово
Раковски
Болгарево
Ч
Е
Р
Н

03.02.2013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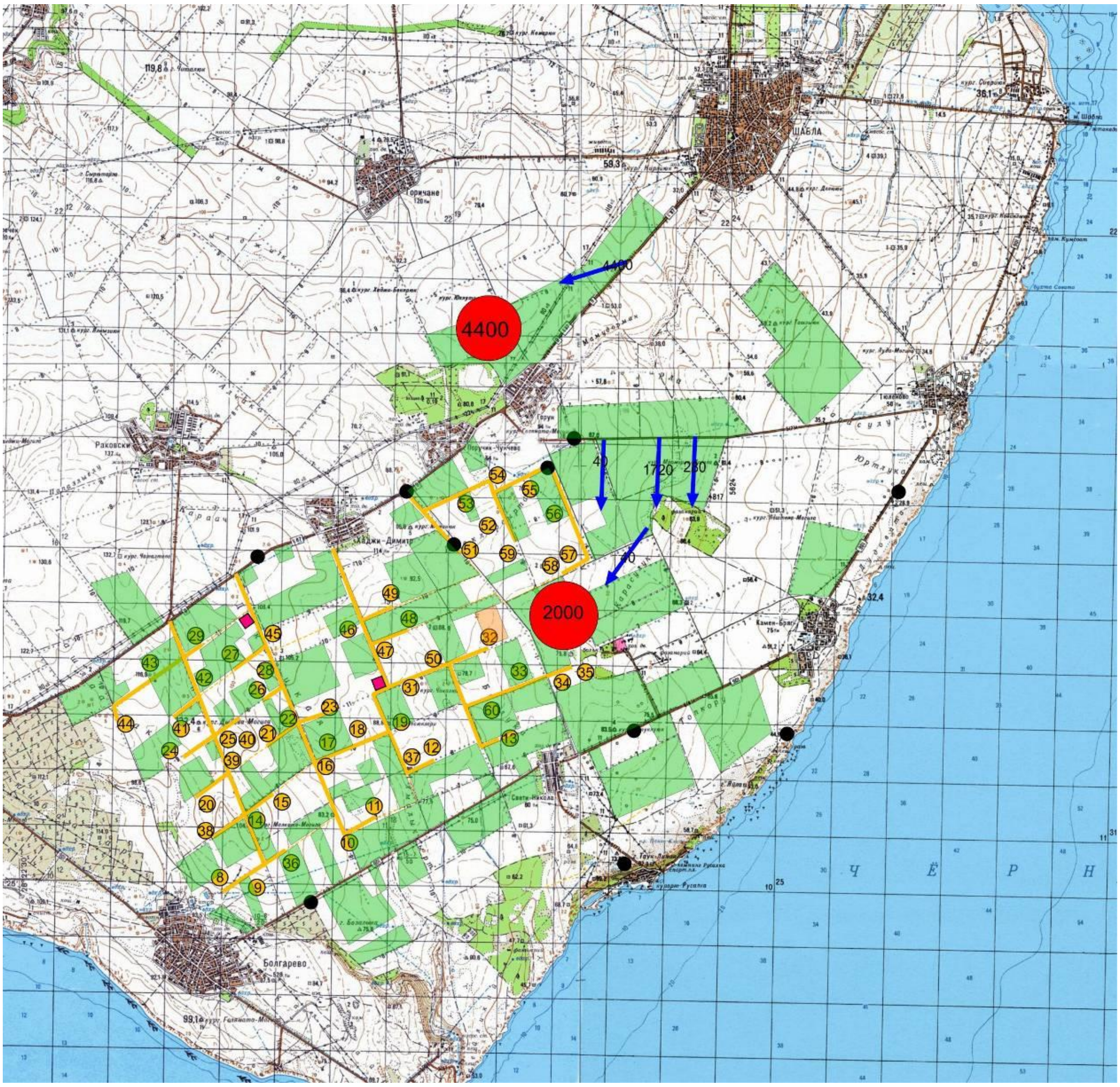
Раковски
Тюленово
Каменя-Бряг
Болгарево

04.02.2012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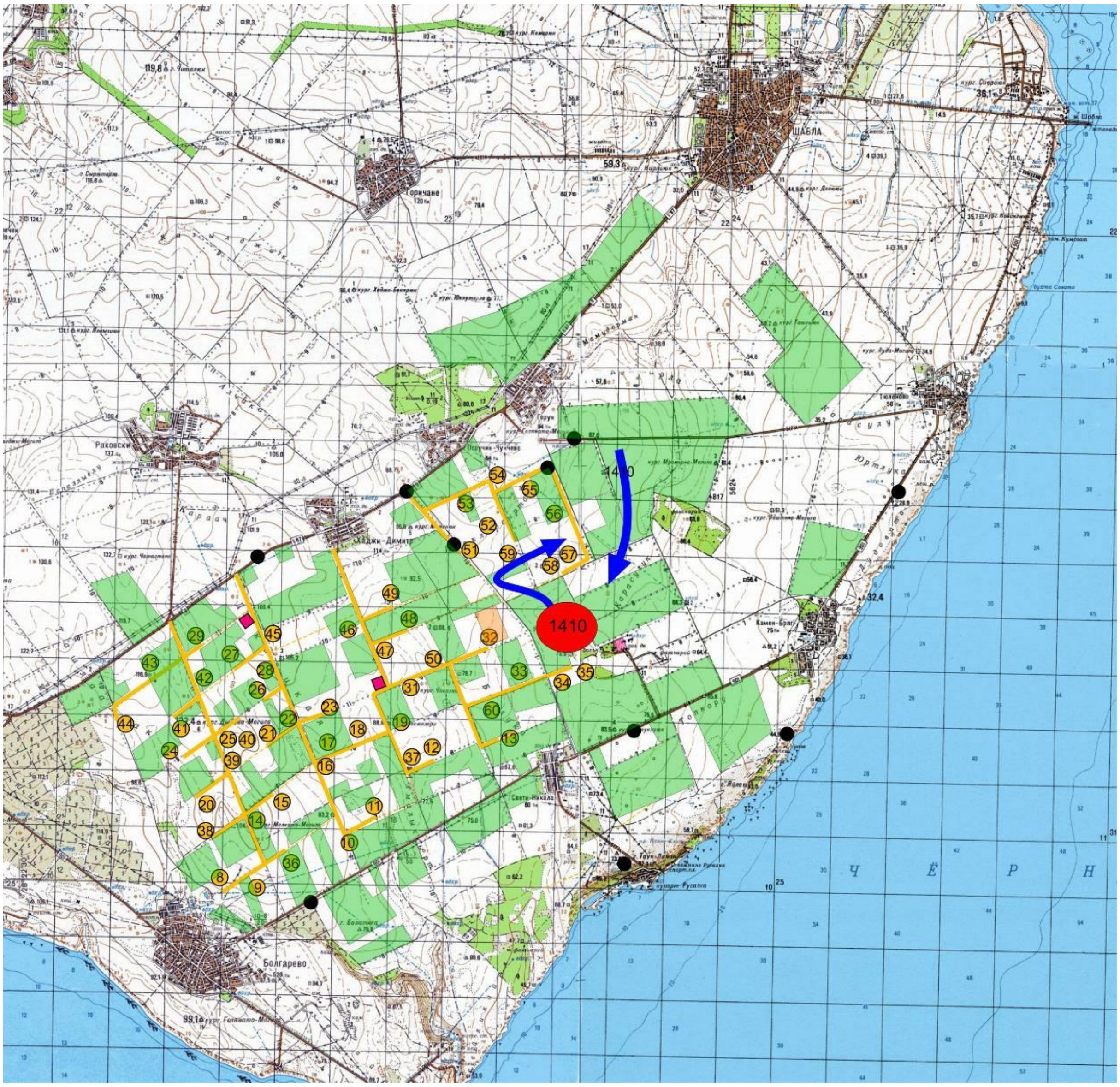
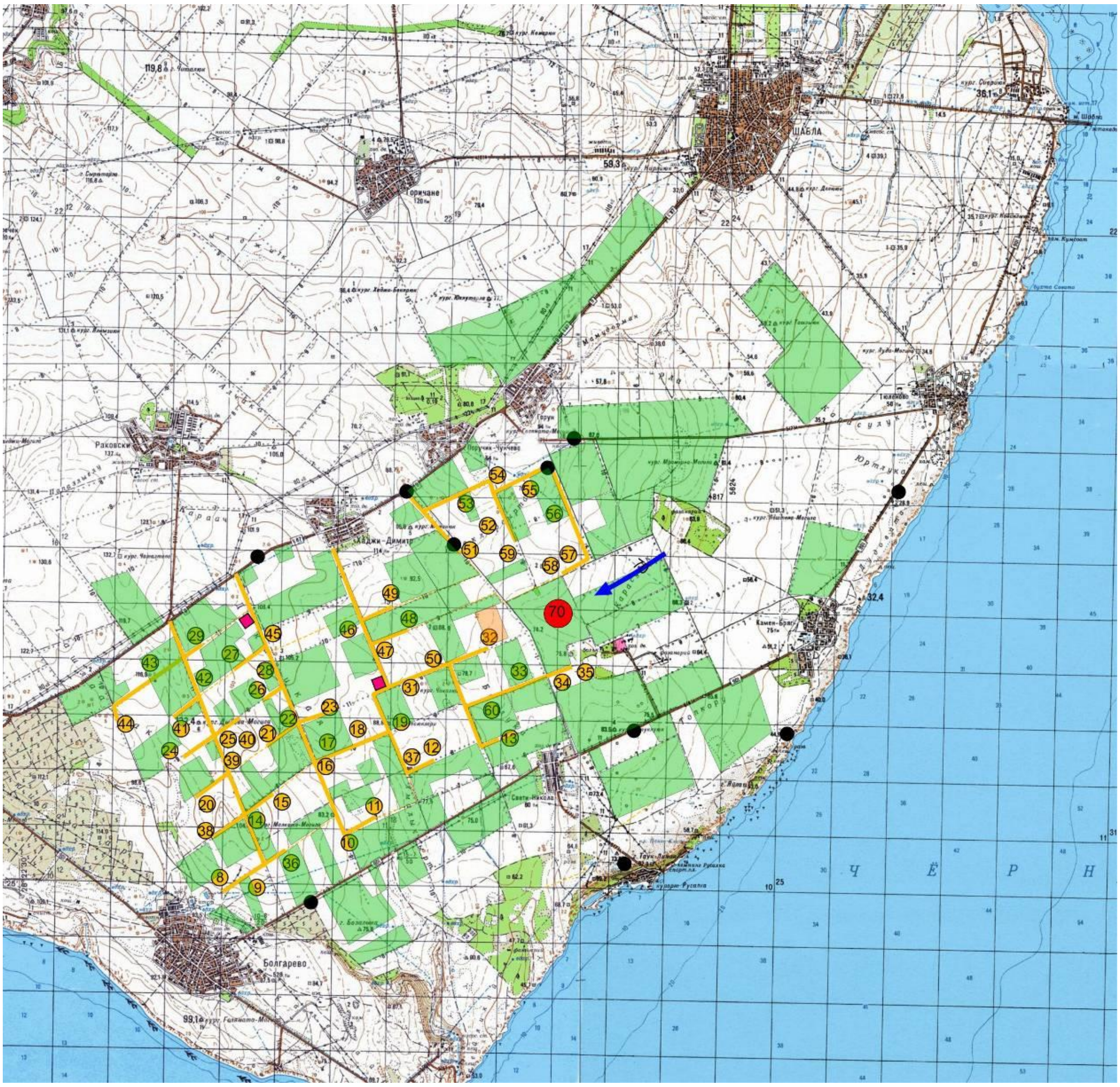
ШАБЛА
Горичане
Раковски
Тюленово
Болгарево

05.02.2013



1410
Шабла
Горичане
Тюленово
Раковски
Болгарево
Свети-Никола
Камен-Бряг
Хаджи-Димитър
Юртлука

09.02.2013



10.02.2013