Appendix A-1

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Background information: summary

The BBC World Service owns and, through a contract with VT Communications, operates 7 high power transmitting stations around the World. Pertinent details are given in the table below.

Site		Senders	Power	Antennas	Location
Antigua		4	250	8 fixed 11 slewable	61º48W 17º06'N
Ascension Island		6	250	7 fixed 22 slewable	14º23'W 07º54'S
Oman	(A'Seelah A)	2 (MF)	800	2 slewable	59º34'E 21º51'N
	(A'Seelah B)	3	250	6 curtain 1 rotatable	21º51'N 59º34'E
Cyprus	(Lady's Mile)	2 (MF)	500	2 fixed	33º00'E 34º40'N
	(Zygi)	1 (MF)	200	1 fixed	33º19'E 34º43'N
		4	300	22 slewable	
		6	250	5 fixed	
Seychelles		4	250	6 slewable	55 28'E 04 36'S
Singapore	(Kranji)	4	100	1 fixed	103º44'E 01º24'N
		5	250	20 slewable	
Thailand	(Nakon Sawan)	5	250	4 fixed 11 slewable	100º04'E 15º03'N

Further details, including frequencies, programme schedules and antenna types, are given in the Appendices.

Appendix A – General Information about BBC World Service MF/HF Transmitting Stations Relevant to RF Hazard Assessment

A1) MF transmitting stations

A1.1) General

Over the MF frequency range (about 530 kHz to 1600 kHz), the wavelength is such that the receiving and transmitting antennas are invariably close to the ground. Coverage relatively close to the transmitter, such as that for domestic services, is therefore provided primarily by ground (surface) wave propagation. Ground conductivity has a significant effect on the attenuation of the wave and therefore on the extent of the service area. Vertical polarisation is invariably used for MF ground wave coverage as horizontally polarised waves suffer much more from ground losses.

Sky wave propagation is used to provide coverage to an area distant from the transmitter. Vertical polarisation is often used for this as the height required for a horizontal radiator, at these frequencies, makes this a less cost-effective option.

Transmitting antennas for MF are usually monopoles above a ground plane. Heights are typically one-quarter wave, but can be up to about a half-wave. A stayed mast or a self-supporting tower is commonly used to form the radiating element. In order to reduce the overall physical height (for reasons of cost), a degree of top loading is sometimes provided. This typically takes the form of a horizontal arrangement of wires, either symmetrical to the vertical element as in a ‘T’ antenna, or asymmetrical as in an inverted ‘L’ In either case two support structures are normally used, with the vertical element also consisting of a number of wires. (The advantage of an inverted T is that there is little resulting radiation from the top, which means that a larger degree of top loading can be provided without affecting the overall efficiency)

The most common feed arrangement for a self supporting tower or stayed mast is provided by insulating the base. An elevated feed is occasionally used with a mast radiator, with an insulator part way up the structure and with the base earthed. Another way of operating with an earthed structure is to form a shunt feed arrangement using either a number of wires in parallel or in the form of a cage around the mast or tower.

Ground planes for MF antennas are normally composed of a system of radial copper wires, typically at 5º spacing, centred on the radiating element. A spacing of 3º is sometimes used when the operating impedance is low, or where a number of vertical radiators are used to form a directional system. Radial earth systems are typically 0.2 to 0.25 λ in length and use wire of about 3 mm in diameter. To avoid damage, and also for security reasons, they are usually but not always buried in the ground. The depth is typically 200 mm to 600 mm, depending on the use of the land (this is sometimes cultivated but more normally used for grazing). The need for such an earth system(s) dictates the minimum size of the site.

Directional MF antenna systems are used to provide a higher field strength (over a limited arc), for a given transmitter power, and/or to restrict interference to other services on the same frequency. Combinations of typically 2 to 6 vertical radiators are used in an in-line and/or broadside arrangement. Individual radiators are driven or tuned as parasitic elements.

A1.2) MF stations used for BBC World Service

MF stations operated by VT Merlin Communications, on behalf of BBC World Service, are located at Orfordness (Suffolk), Cyprus (Lady’s Mile and Zygi) and A’Seelah (Oman). These are all high power stations with transmitter powers ranging from 200 kW to 800 kW. (BBC World Service also uses a number of low-power MF transmitting stations operated overseas by other service providers.)

These VT Merlin Communications stations all have directional MF antenna systems using towers, some driven, and some tuned as parasitic elements. All are base fed apart from the one at Zygi and one of the arrays at Orfordness, which use shunt feeding arrangements.

Ground conditions vary from dry desert (A'Seelah) to salt water saturated (Lady's Mile in the winter months)

Details of sites		Frequency	Bearing	Power
Cyprus (Lady's Mile)	Array 1	639kHz only	180º only	500kW
Cyprus (Lady's Mile)	Array 2	720kHz only	100º only	500kW

Array type (both): - Rectangular array using 4 towers as vertical radiators, each 0.25 λ high with buried radial earth systems.
Tower spacing: In-line 0.25 λ, broadside 0.5 λ.
Tower currents: Front two towers base driven in-phase with equal amplitude; rear towers tuned for equal amplitude and quadrature phase.

Cyprus (Zygi)	Array MF1	1323kHz only	170º only	200kW

Array type:- 2 element array using towers as vertical radiators, each very approximately 0.25 λ high with buried radial earth systems.
Tower spacing: Approximately 0.16 λ
Tower currents: Front tower driven (shunt feed), rear tower used as parasitic reflector.
Note: This site is used mainly for HF and there is known to be some coupling between the MF array and other arrays and supporting structures on the site, particularly Array 60

Orfordness	Array ORF1	648kHz only	131º only	600kW

Array type: 5-element linear array using towers as vertical radiators, each approximately 0.25 λ high with radial earth systems laid on shingle.

Orfordness	Array ORF2	1296kHz only	096º only	500kW

Array type: 6-element array formed from two side-by side 3-element Yagi arrays using towers as vertical radiators, each approximately 0.25 λ high with radial earth systems laid on shingle. All towers are directly earthed with cage feeds to the two central ones.

A1.3) Radiation hazard assessment at MF broadcasting stations

A1.3.1) Nature of the field at MF sites

At MF sites the electric field appears to be predominantly vertical and reasonably uniform (due to the relatively large wavelength). However, measurements made using hand held meters can show poor repeatability, mainly due to the interaction with the body. In particular, the type of (single plane) meter that was traditionally used at BBC MF sites suffered quite badly from this problem. It is also the case that at MF the near field extends a considerable distance and radiation hazard measurements are typically made well within one wavelength of the antenna. This may account for the fact that at MF there can be considerable differences in the readings of meters from different manufacturers, even when they have been calibrated in the same way (under plane wave conditions)

A1.3.2) Hazard assessment for MF sites

At MF sites the body (standing) is aligned with the major component of the field, and in this respect represents one of the conditions under which reference/ investigation levels are derived. However, there may be some differences in other ways, as follows:

a) Meters may respond differently to the 'reactive' component of the near field compared with the radiated component (note that they are only calibrated in far-field conditions)
b) There is some variation of electric field within the space represented by the dimensions of the human body.

c) The current density in the body may have a different relationship to the 'reactive' components of the near field, compared with the radiated component (note that reference/ investigation levels are derived from far-field conditions)
d) The body is earthed, but the ground plane is only partially conducting.

A2) HF transmitting stations

A2.1) General

The BBC's HF broadcast transmitting stations mainly use horizontally polarised curtain or broadside arrays, although log-periodic antennas are occasionally used. A curtain array consists of a vertical matrix of horizontal dipole elements, usually with a reflecting screen behind the dipoles; see A2.2. below. The main signal beam fires orthogonally to the matrix and the antenna will often be capable of operation over a frequency range of up to about 2:1. Arrays typically consist of 16 half-wave dipoles, 4 wide and 4 high, but 2 x 4 and 4 x 2 not uncommon. The dipoles are usually folded and driven from vertical open-wire balanced feeders. The vertical feeders are connected together close to the ground using balanced feeder such that all dipoles are nominally operating in phase. The beam can be slewed horizontally by offsetting the phase of the vertical feeders. Curtain antennas are categorised as:

HRRSn/m/h where

H – Horizontal
R – Array with Reflector
R – Also Reversible (if second "R" present)
S – Slewable (electrically; by adjusting the phase of signals to the dipole elements[1]. The maximum available slew is plus or minus 30º)
n – number of rows of dipoles
m – number of columns of dipoles
h – height above ground of lowest row of dipoles (in wavelengths)

An HRS2/4/0.5 would consist of four columns of two dipoles with the two lowest dipoles 0.5λ above the ground. An H1/1/0.5 antenna would consist of a single dipole 0.5λ above the ground; such an antenna would fire generally upward. Certain antennas also have "A", "B" and "C" modes:
The "A" mode uses only half (two of four) of the vertical columns effectively widening the horizontal aperture of the antenna.
The "B" mode uses the other half (other two of four) vertical columns where these can be fed separately from the "A" half. Here the "A" and "B" modes can be separately fed at the same time so that the whole antenna could carry double the normal transmitter power.
The "C" mode uses two vertical columns from an antenna which was originally designed and constructed with six vertical columns – effectively an HRXx/6/z has been divided into an HRXx/4/z (the main antenna) and an HRXx/2/z (the "C" mode). Both can be fed separately at the same time.

A2.2) HF stations used for BBC World Service

BBC World Service broadcasts from high power HF stations in Cyprus, Antigua, Ascension Island, Oman, Seychelles, Singapore and Thailand. VT Merlin Communications also operate HF stations on behalf of BBC World Service in the UK. These are at Rampisham (Dorset), Woofferton (Shropshire) and Skelton (Cumbria)

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[1] One of the BBC's antennas at the A'Seelah Site in Oman is mechanically steerable.

Transmitter powers are mainly 250/300 kW, but some 100 kW transmitters are still used and the Rampisham station has 10 500kW transmitters. Current transmission frequencies for these sites are in the 4, 6, 7, 9, 11, 13, 15, 17 and 21 MHz broadcast bands (see also Appendix B). A complete list of all the antennas at the Antigua, Cyprus, and Rampisham stations is given in Tables A1, A2, and A3

The antennas are all curtain arrays, supplied by a small number of manufacturers. The differences between these are however quite small. The TCI Model 611 is typical of those used; see http://www.tcibr.com/PDFs/611webs.pdf for details. NB: Data contained at the web link is courtesy of TCI International, Inc.

Self supporting towers are generally used as support structures although some stayed masts are also in use. In Oman a single rotatable curtain array has been installed. Note that both MF and HF is used at the stations in Oman and Cyprus (Zygi)

A2.3) Radiation hazard assessment at HF broadcasting stations

A2.3.1) Nature of the field at HF sites

At HF sites, close to a typical array, the electric field is a combination of horizontal, vertical and outward components. Further away from the array, at distances where the ICNIRP public exposure reference levels would expect to be found, the field usually appears to be mainly horizontally polarised.

A significant spatial variation in the field strength is often found. This can be due to the presence of the body, or other objects, but is also due to the fairly consistent variation with height. This increase in field strength with height is to be expected as the array is designed to a have a fairly narrow beam with maximum radiated power at an elevation angle of around 10º. The variation with height is not just a function of the array itself, but is also partly determined by the ground reflection. The field can therefore be expected to vary with ground conditions.

The difference in the readings of meters from different manufacturers was often found to be less significant at HF than at MF. There were however significant differences between the old BBC designed meter (ME1/2) and commercial meters, when used close to a curtain array. (The ME1/2 was a passive device with much larger elements than commercial meters. It was not very sensitive and so could only be used in relatively high field strength locations) The difference in readings may have been due to near field effects.

A2.3.2) Hazard assessment for HF sites

The same measurement and body absorption issues as mentioned in 1.3.2 in connection with the near field at MF may also apply to HF, possibly to a smaller extent. However, at HF the field variation with height is significant, as is the fact that the body is not aligned with the major component of the field, particularly further away from an array.

Furthermore, even with outstretched arms, or a body suspended horizontally (hammock), the coupling from the horizontal component is likely to be considerably lower than the coupling in the grounded standing position from a vertical field component of similar level. This is because the ‘outstretched arms/ hammock’ condition equates to an isolated body (short dipole) in free space and at these frequencies (i.e. below body resonance) the coupling is significantly lower than in the grounded condition (short monopole above an earth plane)

Table A1 - Antigua HF Antenna List

No.	Frequency Bands MHz	Form		Bore sight (of true N) ºE	Slews
1	9, 11	HR2/2/0.5	1	235	
2	6	HR1/1/0.5		205	
3	15, 17	HRS4/2/0.75	1	205	205A, 193
4	15, 17	HR2/2/0.75	1	205	
5	9, 11	HR2/2/0.75	1	205	
6	9, 11	HR2/2/0.75	1	270	
7	6	HRR2/2/0.5		160 / 340	
8	6	HR2/2/0.75		340	
9	9, 11	HRR2/2/0.75	1	160 / 340	
10	15, 17	HRR4/2/0.75	1	160 / 340	160A, 340A
10C	15, 17	HRR2/2/0.75	1	160 / 340	
11	9, 11	HRR2/2/0.75		160 / 340	
12	6	H1/1/0.5	1	160 / 340	
13	9, 11	HRR2/2/0.75	1	160 / 340	
14	6	HR1/1/0.5		235	
15	15, 17	HR2/2/0.75		300	
16	9, 11	HRS4/2/0.75	1	300	290, 310, 300A, 300B
17	15, 17	HRS4/2/0.75	1	300	290, 310, 300B
18	6	HRS4/2/0.75	1	300	290, 310, 300B

Table A2 - Cyprus (Zygi) HF Antenna List

Old Antennas

No.		Frequency Bands MHz	Form	Bore sight (of true N) ºE	Slews
50					
51		6, 7, 9, 11	HRS4/2/0.55	315	325, 335
52		6, 7, 9, 11	HRS2/2/0.5	328	342
55		9, 11, 13, 15, 17	HRS4/2/0.55	359	329
56		6, 7, 9, 11	HR2/2/0.5	327	
57		9, 11, 13, 15, 17	HRS4/2/0.5	147	117, 160, 175, 147A
58		9, 11, 13, 15, 17	HR2/2/0.5	050	
59	3	6, 7, 9, 11	HRS2/2/0.5	177	162, 192
60		6, 7, 9, 11	HRS4/2/0.55	007	337, 037, 007A
61		9, 11, 13, 15,17	HRS4/2/0.55	007	337, 037, 007A
62		6, 7, 9, 11	HR2/2/0.55	101	
63		6, 7, 9, 11	HRS4/2/0.55	101	89, 113, 101A
64		6, 7, 9, 11	HRS4/2/0.55	077	047, 102
65	3	9, 11, 13, 15, 17	HRS4/2/0.5	077	047, 107
66		6, 7, 9, 11	HRS4/2/0.5	077	047, 107
67	3	11, 13, 15, 17, 21	HRS4/4/0.5	077	092, 102, 077A, 092A
68	3	11, 13, 15, 17, 21	HRS4/4/0.5	173	160, 185, 173A
69	3	6, 7, 9, 11	HRS4/2/0.5	185	160, 175, 185A
70	3	9, 11, 13, 15, 17	HRS 4/4/0.5	173	160, 185, 173A
71	3	6, 7, 9, 11	HRS2/2/0.3	185	170
72	3	9, 11, 13, 15, 17	HRS4/2/0.55	287	280, 295
73	3	6, 7, 9, 11	HRS4/2/0.5	281	295
74		11, 13, 15, 17, 21	HRS4/2/0.55	187	175, 187A
75		11, 13, 15, 17, 21	HRRS2/2/0.5	345 / 165	330 / 140, 180
76	3	6, 7, 9, 11	HR2/10/0.3	005	
77	3	4	HRR1/1/0.3	028 / 208	
83	2	6, 7, 9, 11	HRS4/2/0.5	328	314, 335, 358, 328A

84	2	6, 7, 9, 11	HRS4/2/0.55	359	329, 335, 359A

Replacement Antennas 3

59	11, 13, 15, 17, 21	HRS4/3/1	177	160
65A	6, 7, 9, 11	HRS2/2/0.5	077	64, 90
65B	13, 15, 17, 21	HRS2/2/0.5	077	64, 90
67	9, 11, 13, 15, 17	HRS3/4/0.5	077	57, 97
68	6, 7, 9, 11	HR2/2/0.5	173	
69	6, 7, 9, 11	HRS4/2/0.55	185	160, 175
70	9, 11, 13, 15, 17	HRS4/4/0.5	173	160
71	6, 7, 9, 11	HRS4/2/0.55	185	170
72	9, 11, 13, 15, 17	HRS4/2/0.5	280	288
73	6, 7, 9, 11	HRS4/2/0.5	281	295
77	4	HRR1/1/0.3	028 / 208	

Table A3 - Rampisham HF Antenna List

No.	Frequency Bands MHz	Form	Bore sight ºE (of true N)	Slews
1	6, 7, 9, 11	HRS4/4/0.5	105	85, 95, 115
2	6, 7, 9, 11	HRS4/4/0.5	105	85, 95, 115
3	9, 11, 13, 15, 17	HRS4/4/0.5	105	95, 115
4	6, 7, 9, 11	HRS2/2/0.5	168	
5	6, 7, 9, 11	HRS2/2/0.5	168	
6	6, 7, 9, 11	HR4/2/0.7	48	
7	9, 11, 13, 15, 17	HR2/4/0.5	62	
8	9, 11, 13, 15, 17	HRS4/4/0.5	62	48
9	6, 7, 9, 11	HR2/4/0.5	62	
10	9, 11, 13, 15, 17	HRS4/4/0.5	62	48, 76
11	11, 13, 15, 17, 21	HRS4/4/0.5	62	48, 92
12	11, 13, 15, 17, 21	HR2/4/0.5	62	
13	6, 7, 9, 11	HRS4/2/0.3	190	180, 200
14	6, 7, 9, 11	HRS4/2/0.4	190	180, 200, 190A
15	6, 7, 9, 11	HR2/2/0.4	140	
16	6, 7, 9, 11	HRS4/4/0.5	140	120, 160
17	11, 13, 15, 17, 21	HR2/2/0.5	168	
18	11, 13, 15, 17, 21	HR2/2/0.5	168	
19	11, 13, 15, 17, 21	HRS4/2/0.5	105	95, 105
20	11, 13, 15, 17, 21	HRS4/4/0.5	105	85, 95, 115, 125
21	7, 9, 11	HRS4/4/0.5	285	260, 270, 300, 310
22	6, 7, 9, 11	HRS4/4/0.73	47	33, 61
23	6, 7, 9, 11	HR4/4/0.85	62	
24	6, 7, 9, 11	HRS4/4/0.85	62	48, 76
25	11, 13, 15, 17, 21	HRS4/4/0.5	189	169, 209
26	11, 13, 15, 17, 21	HRS4/4/0.5	47	61
27	11, 13, 15, 17, 21	HRS4/4/0.57	47	61
28	6, 7, 9, 11	HRS4/4/0.5	227	
29	6, 7, 9, 11	HRS4/2/0.5	95	80, 110
30	6, 7, 9, 11	HRS4/4/0.5	275	260, 300
31	9, 11, 13, 15, 17	HRS4/2/0.5	95	80, 110
32	6, 7, 9, 11	HRS4/4/0.5	275	260, 300
33	6, 7, 9, 11	HRS4/2/0.5	95	80, 110
34	6, 7, 9, 11	HRS4/2/0.5	95	80, 110

Note 1 – These antennas are non-standard in that the separation of the horizontal rows of dipoles is 0.6 λ. The Form stated in the table is the "effective" form were the antennas of a more conventional design.

Note2 – These antennas have diplexers which allow two transmitters to feed the antenna simultaneously, doubling the power output from the antenna

Note 3 – The Cyprus (Zygi) antennas are currently being rebuilt. It is expected that the antennas entered in red type in the table will have been replaced at the time the survey takes place.