APPENDIX A

REVISED PROPOSED CHECKLIST

CHECKLIST TO DETERMINE IF COMPUTER MODELING MAY REPLACE FIELD PROOF-OF-PERFORMANCE MEASUREMENTS FOR A PARTICULAR AM DIRECTIONAL ARRAY

I. ARRAY REQUIREMENTS.

1. Does the array have six or fewer towers?

   [ ] Yes. (Go to question 2.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

2. Do all of the towers in the array have face widths that, throughout their height, never exceed 2,500/f(kHz) meters [8,202/f(kHz) feet] (3 electrical degrees)?

   [ ] Yes. (Go to question 3.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

3. *Based upon a licensed surveyor's affidavit*, is the difference in elevation between the lowest tower base in the array and the highest tower base in the array less than or equal to 5,000/f(kHz) meters [16,404/f(kHz) feet] (6 electrical degrees)?

   [ ] Yes. (Go to question 4.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

4. *Based upon a licensed surveyor's affidavit*, is the difference in ground elevation between the tower at the lowest ground elevation and the tower at the highest ground elevation in the array less than or equal to 5,000/f(kHz) meters [16,404/f(kHz) feet] (6 electrical degrees)?

   [ ] Yes. (Go to question 5.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

5. Is there a post-construction surveyor's affidavit confirming that each tower in the array is located, relative to the array reference point (this may not necessarily be the center of the array), within 417/f(kHz) meters [1,367/f(kHz) feet] (0.5 electrical degrees) of the location specified on the station's FCC construction permit?

   [ ] Yes. (This affidavit must be on file at the station. Go to question 6.)
   [ ] No. (Computer modeling will only be permitted to replace field proofs if a post-construction surveyor's affidavit is available.)

6. Does dividing the array's theoretical RSS value by its theoretical RMS value result in a number that is less than or equal to 1.50?

   [ ] Yes. (Go to question 9.)
   [ ] No. (Go to question 7.)

7. Does dividing the array's theoretical RSS value by its theoretical RMS value result in a number that is less than or equal to 1.75 AND does the array have five or fewer towers?

   [ ] Yes. (Go to question 9.)
   [ ] No. (Go to question 8.)

8. Does dividing the array's theoretical RSS value by its theoretical RMS value result in a number that is less than or equal to 2.00 AND does the array have four or fewer towers?

   [ ] Yes. (Go to question 9.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

II. SAMPLING SYSTEM REQUIREMENTS.

9. If current sampling loops are used to measure the current in each tower of the array, are the loops installed in exactly the same configuration on each tower, are they installed at the height on each tower where the current will be at a minimum when the tower is detuned, *are the sampling loops mounted on insulators and bonded to their towers at the coax connector end only*, AND at any given height does the cross section of each tower in the array equal the cross section of all other towers in the array? (If current sampling loops are not used to measure the current in each tower of the array, go to question 10.)

   [ ] Yes. (Go to question 12.)
   [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

10. If base current sampling transformers are used to measure the current in each tower of the array, are all of the towers in the array less than or equal to 115 electrical degrees in height, or greater than or equal to 210 electrical degrees in height AND less than or equal to 225 electrical degrees in height? (If base current sampling transformers are not used to measure the current in each tower of the array, go to question 11.)

    [ ] Yes. (Go to question 12.)
    [ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

11. If base voltage samplers are used to measure the current in each tower of the array, are all of the towers in the array greater than or equal to 105 electrical degrees in height AND less than or equal to 220 electrical degrees in height?

[ ] Yes. (Go to question 12.)
[ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

12. Do the sampling system transmission lines for each tower:

a) have solid outer conductors;
b) have constant impedance throughout their lengths regardless of any splices; AND
c) have equal electrical lengths, as determined by post-construction electrical measurements that are on file at the station?

[ ] Yes. (Go to question 13.)
[ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

III. ARRAY ENVIRONMENT REQUIREMENTS.

13. Are there *any* high tension power lines or elevated bridges taller than 22,500/f(kHz) meters [73,819/f(kHz) feet] (0.075 wavelengths) within 3,000/f(kHz) kilometers [1,864/f(kHz) miles] (ten wavelengths) of the reference coordinates of the array?

[ ] Yes. (Computer modeling is not permitted to replace field proofs for this array.)
[ ] No. (Go to question 14.)

14. Are there any conducting structures *not controlled by the AM licensee* and taller than 22,500/f(kHz) meters [73,819/f(kHz) feet] (0.075 wavelengths) within 300,000/f(kHz) meters [984,252/f(kHz) feet] (one wavelength) of the reference coordinates of the array?

[ ] Yes. (Computer modeling is not permitted to replace field proofs for this array.)
[ ] No. (Go to question 15.)

15. Do the heights of all reradiating objects *not controlled by the AM licensee* that lie beyond one, and out to ten wavelengths from the reference coordinates of the array comply with the following formula?

$$h \leq 0.01(r) + 0.06\lambda$$

Where h = height of reradiating structure (meters)
λ = wavelength of AM station (meters)
r = distance from array reference coordinates to reradiating structure (meters)

[ ] Yes. (Computer modeling is permitted to replace field proofs for this array. Go to 18.)
[ ] No. (Go to question 16.)

16. Do the heights of all reradiating objects *not controlled by the AM licensee* that lie beyond one, and out to ten wavelengths from the reference coordinates of the array AND that have radii no greater than 0.01 wavelengths comply with the following formula?

$$h \leq 0.082\lambda \log\left[1.786\left(r/\lambda\right)\frac{E_{null}}{E_{IDF}}\right] - 5ao + 0.248\lambda$$

$$For \quad h \geq 0.075\lambda \quad and \quad ao \leq 0.01\lambda$$

Where a_o = radius of reradiating structure (meters)
h = height of reradiating structure (meters)
λ = wavelength of AM station (meters)
E_{IDF} = standard pattern IDF at azimuth toward reradiating structure (maximum IDF over the arc subtended by the reradiating structure)
E_{null} = standard pattern IDF at absolute pattern minimum
r = distance from array reference coordinates to reradiating structure (meters)

[ ] Yes. (Go to question 17.)
[ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

17. Do the heights of all reradiating objects *not controlled by the AM licensee* that lie beyond one, and out to ten wavelengths from the reference coordinates of the array AND that have face widths no greater than 0.1 wavelengths comply with the following formula?

$$h \leq 0.09\lambda \log\left[1.786\left(r/\lambda\right)\frac{E_{null}}{E_{IDF}}\right] - 0.8w + 0.226\lambda$$

$$For \quad h \geq 0.075\lambda \quad and \quad 0.01\lambda \leq w \leq 0.1\lambda$$

Where w = building face width (meters)
h = height of reradiating structure (meters)
λ = wavelength of AM station (meters)
E_{IDF} = standard pattern IDF at azimuth toward reradiating structure (maximum IDF over the arc subtended by the reradiating structure)
E_{null} = standard pattern IDF at absolute pattern minimum
r = distance from array reference coordinates to reradiating structure (meters)

[ ] Yes. (Computer modeling is permitted to replace field proofs for this array. Go to 18.)
[ ] No. (Computer modeling is not permitted to replace field proofs for this array.)

18. Are all reradiating structures controlled by the AM licensee and taller than 22,500/f(kHz) meters [73,819/f(kHz) feet] (0.075 wavelengths) within 300,000/f(kHz) meters [984,252/f(kHz) feet] (one wavelength) of the reference coordinates of the array? If yes, all reradiating objects controlled by the AM licensee that lie beyond one, and out to ten wavelengths from the reference coordinates of the array that do *not* comply with the following formula:

$$h \leq 0.01(r) + 0.06\lambda$$

Where h = height of reradiating structure (meters)
λ = wavelength of AM station (meters)
r = distance from array reference coordinates to reradiating structure (meters)

must be effectively detuned by the AM licensee and, if the height of the reradiating structure exceeds 37,500/f(kHz) meters [123,031/f(kHz) feet] (45 electrical degrees) at the AM frequency, it must be monitored by the AM licensee to ensure that the detuning remains effective.

[Note: #18 was previously part j) of Section IV.]

IV. COMPUTER MODEL REQUIREMENTS.

19. In order to replace field proofs with computer modeling, the computer model must meet certain requirements. These are:

a) The model must *be a public domain version of MINNINEC available at no cost*;

b) *Perfectly conducting earth must be assumed*;

c) The radius of the cylinder used to model each tower must be equal to 0.37 times the face width of a triangular tower, and 0.56 times the face width of a square tower;

d) The number of cylinder segments used to model each tower must be equal to the height of the tower, in electrical degrees, divided by ten and rounded up to the nearest multiple of three (tower height in feet x frequency in kHz ÷ 27,340 rounded up to the nearest multiple of three), OR, for towers no taller than 60 electrical degrees (164,040 ÷ frequency in kHz, feet), nine cylinder segments must be used to model each tower;

e) Each of the cylinder segments used to model each tower must be of equal length;

f) The modeled height of each tower in the array must be no greater than 110 percent, and no less than 100 percent, of the tower's physical height;

g) The series inductance used to model the hookup inductance between the output port of each antenna tuning unit and its associated tower and the internal inductance of the ground system must be no greater than 10 μH;

h) The shunt capacitance used to model capacitance effects at the base of each tower must be no greater than 150 pF plus the sum total of the manufacturer's stated, or separately measured, capacitances for any devices appearing across the tower base after the output port of its associated antenna tuning unit; and

i) The tower impedance values to be used in the model must be the measured impedance values at the output port of each tower's tuning unit (at the point where its base current or voltage sampling device, if employed, is installed) while all of the other towers in the array are shorted from their measurement points to the reference grounds of their output ports. The measured tower impedance values must be within ±4.0 percent and 2 Ω of those used in the model, for both resistance and reactance.

APPENDIX B

ENGINEERING STATEMENT
CONCERNING AM DA PATTERN ADJUSTMENTS
TO ANTENNA MONITOR PARAMETERS DETERMINED
FROM MOMENT METHOD MODELING

It is impossible to provide comprehensive detail on the history of adjusting AM directional antenna systems with moment method modeled parameters because, in general, antenna monitor sampling systems have not been installed and tested with absolute measurement accuracy in mind. Additionally, we generally do not go to the extent that has been suggested in the Docket 93-177 Rulemaking for adjusting the moment method model to duplicate measured as-built base impedance values since modeled values for generic assumptions have been found to produce good starting points for the type of monitor-point-tolerance-optimization adjustments that are often done before running field strength proofs-of-performance.

In the experience of this firm, even with sampling systems that do not meet the kind of requirements that have been suggested for use with moment method modeled parameters, the patterns that we have adjusted to moment method modeled parameters either demonstrate compliance with construction permit standard patterns or null radial excesses of typically one or two dB. The following three examples demonstrate the range of results that we have experienced for arrays constructed on property meeting the proposed requirements for nearby terrain and absence of reradiating structures of the pending moment method modeling Rulemaking. All were proofed while adjusted to their initial moment method model parameters:

EXAMPLE 1 – KTRJ, FRAZIER PARK, CALIFORNIA

KTRJ operates daytime with a three-tower directional antenna on 1050 kilohertz. The directional antenna system was adjusted and the proof-of-performance was conducted by the undersigned during April and May of 1993. The deepest null in the KTRJ daytime pattern is 20.2 dB below the standard pattern RMS. The RSS/RMS ratio of the pattern is 1.19:1. The measured pattern was completely within the standard pattern. The following is a comparison of measured to standard radiation from the proof-of-performance:

(Azimuth/Measured Field/Standard Field/dB deviation)

18/1854/1886/-0.1
55/1126/1131/-0.0
98.5/60.4/93.6/-3.8
110.5/59.1/114.7/-5.8
121.5/72.5/99.5/-2.7
155/665/688/-0.3
185/1056/1112/-0.4
230.5/497/531/-0.6
262/649/708/-0.8
303.5/398/463/-1.3
345/1311/1327/-0.1

EXAMPLE 2 – WRHB, KENDALL, FLORIDA

WRHB operates DA-2 with a six-tower directional antenna on 1020 kilohertz. The directional antenna system was adjusted and the proof-of-performance was conducted by the undersigned in March of 2001. The deepest nulls in the WRHB daytime and nighttime patterns are 28.3 dB and 21.0 dB below the standard pattern RMS, respectively. The RSS/RMS ratios of the daytime and nighttime patterns are 1.17:1 and 1.18:1, respectively. The measured nighttime pattern was completely within the standard pattern. The measured daytime pattern exceeded the standard pattern at two null azimuths. The following is a comparison of measured to standard radiation from the proof-of-performance:

(Azimuth/Measured Field/Standard Field/dB deviation)

Daytime Pattern:

45/1138/1170/-0.2
84/2166/2200/-0.1
115/887/895/-0.1
143/49.7/34.1/+3.3
180.5/39.2/38.9/+0.1
252.5/502/843/-4.5
300/87.2/153/-4.9
345.5/39.4/60.6/-3.7

Nighttime Pattern:

45/275/284/-0.3
84/763/765/0.0
115/508/518/-0.2
174.5/41.8/50.2/-1.6
235/58.0/81.9/-3.0
283.5/151/157/-0.3
354/19.1/27.9/-3.3

These data clearly indicate that the directional antenna patterns were found to be very close to their respective standard patterns when viewed in dB.

Ronald D. Rackley, P.E.
June 29, 2001

APPENDIX C

COMPUTER MODELING TO PREDICT ACTUAL ANTENNA PERFORMANCE

In the Further Notice of Proposed Rulemaking on the Use of Computer Modeling to Predict Antenna Performance (MM Docket 93-177, FCC 01-60, 3/7/2001, ¶46) the Commission requested that commenters provide comparison of computer modeling and results established by field measurements.

The attached data is provided in connection with the "Joint Comments of Broadcasters, Broadcast Engineering Consultants, and Equipment Manufacturers" by Hatfield & Dawson Consulting Engineers, LLC. The firm was one of the original "joint petitioners" in this proceeding, and members of the firm have been using moment method techniques for design and analysis of antennas and antenna related engineering problems since the original publication of the NEC ("Numerical Electromagnetic Code") and MININEC programs by the U.S. Navy.

A excellent early example of an array whose adjustment was set up entirely by "internal parameters" using the method of moments is the licensed nighttime array of KCIS, Edmonds, WA (630 kHz, 2.5 kW DA-N operation with this array).

The moment method model used 7 segments per antenna element and an equivalent radius of 0.291 meters, and the actual physical heights of the towers (87.6 degrees). The impedance at the base of each tower with the other towers shorted to ground directly across the base insulators was measured to create a matrix for generation of the operating (drive) impedance values for each of the three towers. These measured values were used to determine the assumed tower base insulator capacitance and series inductance to be used with the MININEC model. The drive impedances and the current magnitudes and angles at the sample monitoring location (the tower feeds) were generated by MININEC.

The drive or operating impedance values, together with electrically measured lengths for the feed lines, were used to design the necessary ACU and power division ("phasor") networks. The sample system uses Delta toroidal transformers on the tower feeds from each ACU, and the sample lines were also measured to ensure that they were equal in electrical length.

After all of the networks, ACU and phasor, were set to the design center values, the input common point matching network was trimmed for 50 ohm zero reactance input. At this point the system was operated under power and the sample system parameters read from the antenna monitor.

1 W	0.754	-138.5
2 C	1.0	0.0
3 E	0.338	+145.3

These values are within 1% and 3 degrees of the values predicted by the MININEC moment method program so they were used to generate a set of field values from the same program.

1 W	1.0	0
2 C	1.28	+139.6
3 E	0.416	-72.8

These values are very close to the theoretical field values. The attached patterns (which are

theoretical and not standard pattern plots) show that the resulting pattern has the minor lobe slightly reduced in size from the pattern which is at the design field parameters. This was considered to be desirable for stability purposes (the pattern has an RSS/RMS ratio of 1.4/1) and so no adjustment to the original parameters was made.

The measured field strength is compared to the design theoretical pattern values and the standard pattern values in the following table. Note that the measured field strength values for the minor lobe at 71, 90, and 130 degrees are indeed slightly smaller than the theoretical pattern values for the design parameters, as shown by the moment method analysis.

COMPARISON OF PATTERN INVERSE FIELD VALUES

Azimuth	Theoretical Design	Measured	Standard Pattern
34.5	35.4	35	41.8
71	259.5	195	273.2
91.5	309.8	245	325.8
130	159.3	132	168.4
156	58.8	27	64.6
223	699.7	650	735
270.2	961.9	960	1010
302	848.5	848	891

Note that the measured RMS of the pattern, 512.6 mV/m, is equivalent to 1.5 ohm loss, which is typical, since few antenna systems actually exhibit one ohm loss as required by the standard pattern formula.

The description of the setup and adjustment process filed with the Form 302 license application for KCIS described (in somewhat less detail) the fact that this array was setup and proofed without further adjustment from the moment method generated impedance and antenna monitor values. It is one of many examples of arrays where this method was used and which were determined to produce measured fields well within the "error bars" of the field measurement process. Only in instances where sample system irregularities, nearby re-radiating objects, or other easily observable anomalies have been present have we found moment method generated antenna monitor parameters to produce measured pattern results that are not within the standard pattern values.

The KCIS array setup and verification were also described as one of the examples in the paper "Modern Analysis Methods for Medium Wave Antenna Design" by B. F. Dawson, presented at the International Broadcast Convention ("IBC") 1990, in Brighton, U.K., and in the paper "Nearly Seven Years of Success using MININEC for Analysis of Standard Broadcast Medium Wave AM Directional Antennas" by J. B. Hatfield, presented at the 1994 Symposium of the Applied Computational Electromagnetics Society at the Naval Postgraduate School in Monterey, CA.

July 3, 2001

Benj. F. Dawson III, P.E.
James B. Hatfield, P.E.
Paul W. Leonard, P.E.
Stephen S. Lockwood, P. E.

ATTACHMENTS

1. Theoretical Pattern as Adjusted

2. Theoretical Pattern with Design/Database Parameters

3. Engineering Statement from KCIS 302 License Application

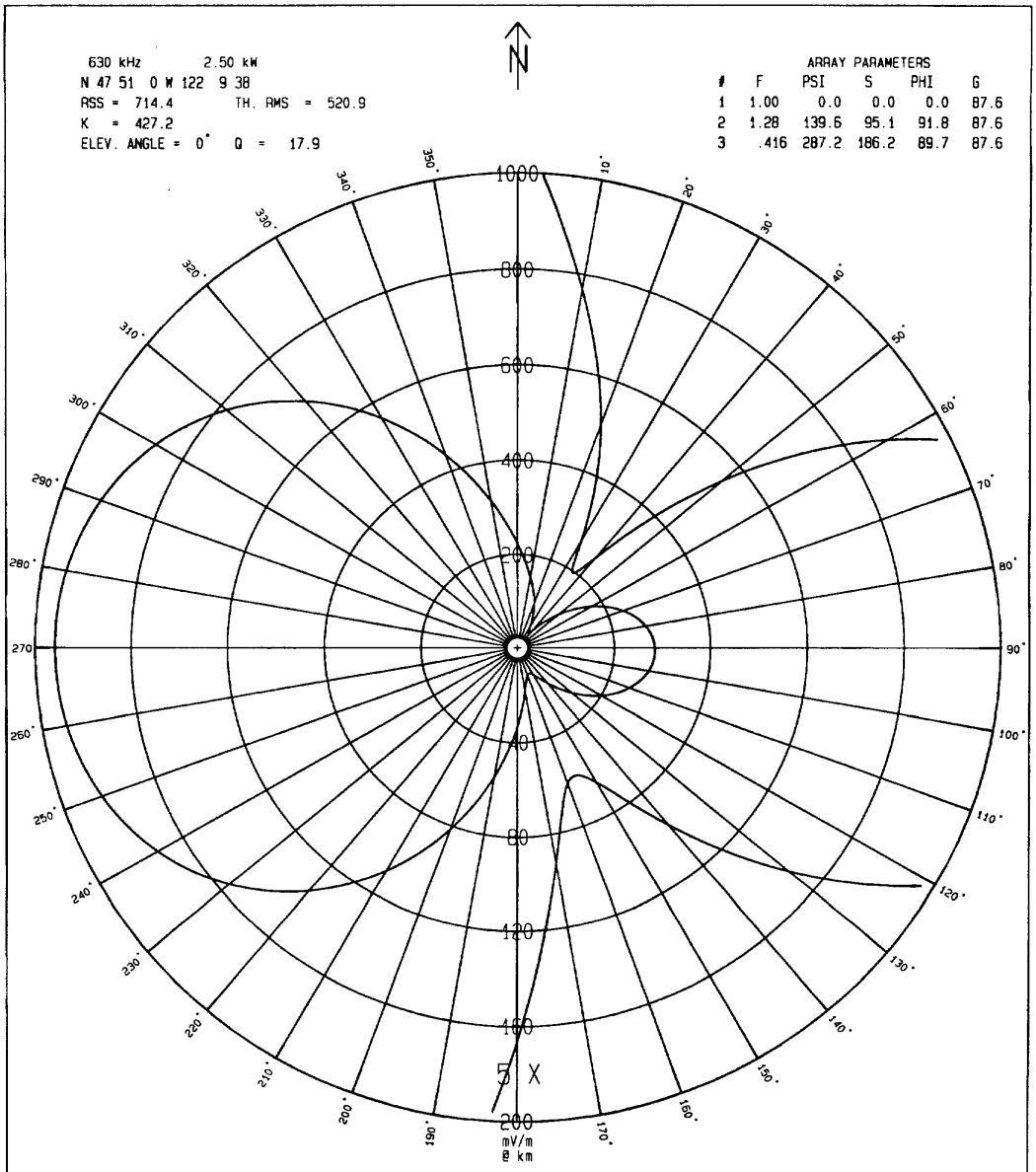
4. Measured Pattern Compated with Standard Pattern from License Application

5. Sample System Description, Measured Field Table, Antenna Monitor Parameters from License Application

630 kHz 2.50 kW
N 47 51 0 W 122 9 38
RSS = 714.4 TH. RMS = 520.9
K = 427.2
ELEV. ANGLE = 0° Q = 17.9

ARRAY PARAMETERS

#	F	PSI	S	PHI	G
1	1.00	0.0	0.0	0.0	87.6
2	1.28	139.6	95.1	91.8	87.6
3	.416	287.2	186.2	89.7	87.6



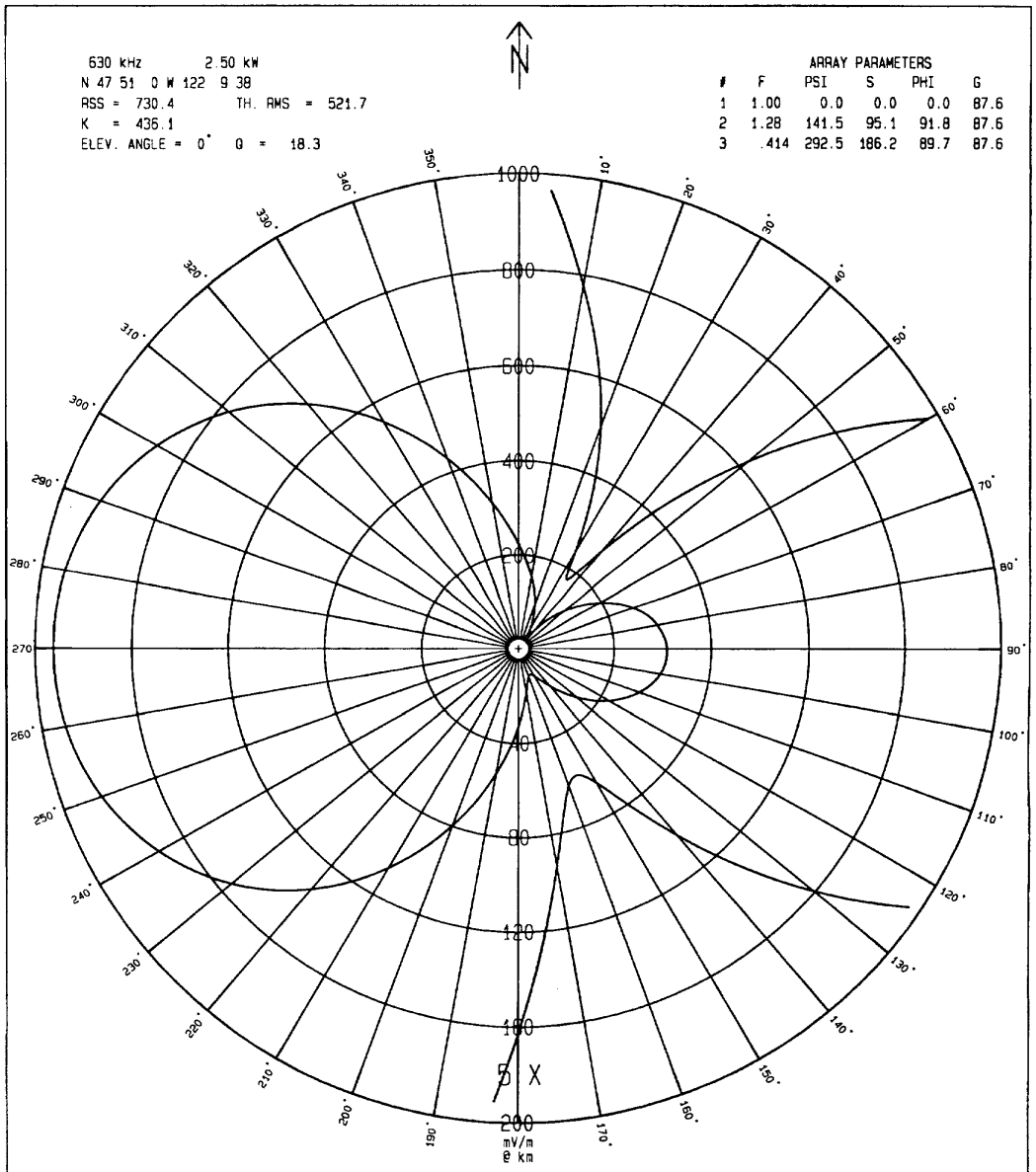
AS ADJUSTED PARAMETERS

HATFIELD & DAWSON CONSULTING ENGINEERS	THEORETICAL PATTERN KCIS EDMONDS, WA US JULY 2001

630 kHz 2.50 kW
N 47 51 0 W 122 9 38
RSS = 730.4 TH. RMS = 521.7
K = 436.1
ELEV. ANGLE = 0° Q = 18.3

ARRAY PARAMETERS

#	F	PSI	S	PHI	G
1	1.00	0.0	0.0	0.0	87.6
2	1.28	141.5	95.1	91.8	87.6
3	.414	292.5	186.2	89.7	87.6



DESIGN DATABASE PARAMETERS

HATFIELD & DAWSON CONSULTING ENGINEERS	THEORETICAL PATTERN KCIS EDMONDS, WA US JULY 2001

ENGINEERING STATEMENT

This directional antenna proof of performance has been made pursuant to the provisions of BP-870827AC. The measurements were taken and analyzed according to the procedures outlined in Section 73.186 of the Commission's Rules and Regulations.

KCIS operates ND 5 kW day and DA 2.5 kW night from separate sites. No changes have been made in the KCIS daytime operation. The KCIS night time directional antenna site was established in 1984 and no changes have been made to the towers, ground system, or antenna monitor sample system since that time. The construction permit is for changes in the directional antenna pattern that is used by the presently licensed DA-N operation of KCIS. The antenna phasing, power division and matching networks have been rebuilt to accommodate the new pattern. No other changes have been made at the KCIS DA-N site.

The directional antenna monitor parameters were derived from the theoretical field parameters shown on the construction permit. The relationship between the field and monitor parameters was found using circuit analysis and moment method procedures. After the components used in the matching, phasing and power division networks were set to the proper reactances no further adjustments were made and the proof of performance field intensity measurements were conducted on the directional pattern.

John Watt made all field intensity measurements using a Potomac Instruments FIM-41 meter. The accuracy of this meter was checked using a recently calibrated meter belonging to Hatfield & Dawson and found to be within the tolerances stated for the meter by the manufacturer. John Watt's experience taking field intensity measurements is a matter of record with the Commission in Washington, D.C.

Resistance and reactance measurements were made by this writer on the DA common input and non directional tower #2 at the locations indicated on the schematic diagram of the antenna phasing and matching circuitry. A Delta OIB-3 bridge and Potomac Synthesizer/Detector SD 31 were used to make the measurements. A known impedance was measured to determine that the accuracy of the measurements was within that specified by the manufacturer for the bridge.

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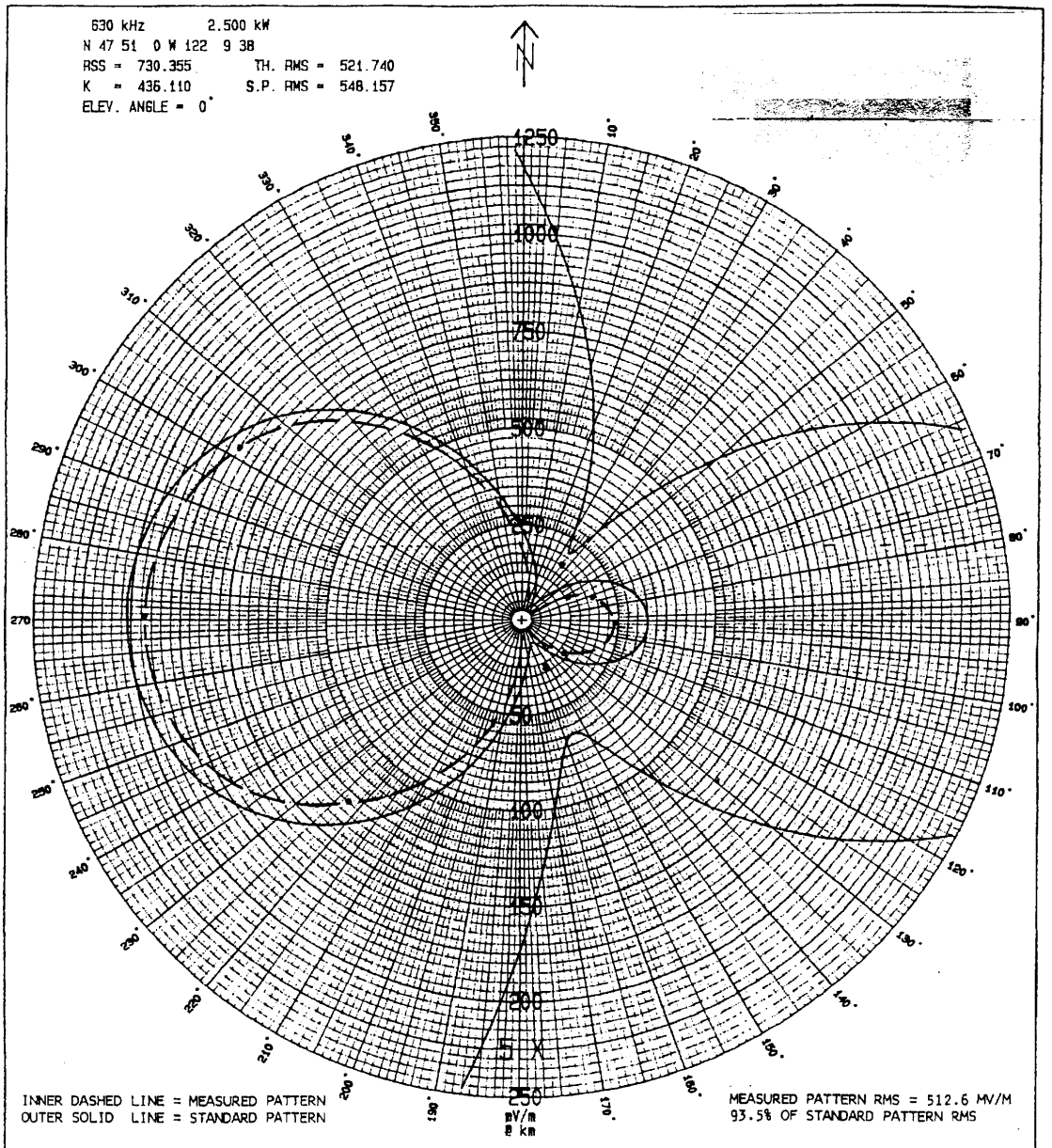
CONSULTING ENGINEERS



HATFIELD & DAWSON CONSULTING ENGINEERS	EXHIBIT ENG RPT MEASURED NIGHTTIME PATTERN KCIS EDMONDS, WA 7/89

SAMPLE SYSTEM STATEMENT

The sample system has not been changed since it was installed in 1984. It consists of equal lengths of solid outer conductor foam heliax connected to Delta current transformers at the towers. The cables were buried so that they experience identical environmental impacts.

MEASURED INVERSE FIELDS

AZIMUTH (Deg. T)	NON DIRECTIONAL 5000W (mV/m)	DIRECTIONAL 2500W (mV/m)	STANDARD PATTERN (mV/m)
34.5	680	35	41.8
71	760	195	273.2
91.5	730	245	325.8
130	760	132	168.4
156	740	27	64.6
223	820	650	735
270.2	670	960	1010
302	765	848	891

MEASURED NON DIRECTIONAL PATTERN RMS = 754 mV/m

MEASURED DIRECTIONAL PATTERN RMS = 513 mV/m

ANTENNA MONITOR PARAMETERS

TOWER	RATIO	PHASE	BASE CURRENT
#1(W)	0.754	-138.5 Deg.	6.0 Amp.
#2(C)	1.0	0.0	7.74
#3(E)	0.338	+145.3	2.59