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ENGINEERING REPORT:

ANALYSIS AND HISTORY OF MEDIUM WAVE ANTENNA SYSTEMS LOCATED IN MERCER SLOUGH

Prepared for

Parks and Community Services Department
City of Bellevue, Washington

November 2002

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Executive Summary

AM (medium wave) radio station antennas and transmitting sites located in Mercer Slough were first established in the early 1960's. The purpose of this report is to provide the background information about why this area was chosen for these facilities in order to assist the City of Bellevue in management of the property leases and to develop guidelines and procedures for the maintenance practices necessary to allow the tenants to properly operate the facilities. The physical properties of medium wave radio propagation make this area an ideal transmitter location and the use is quite compatible with wetlands preservation goals.

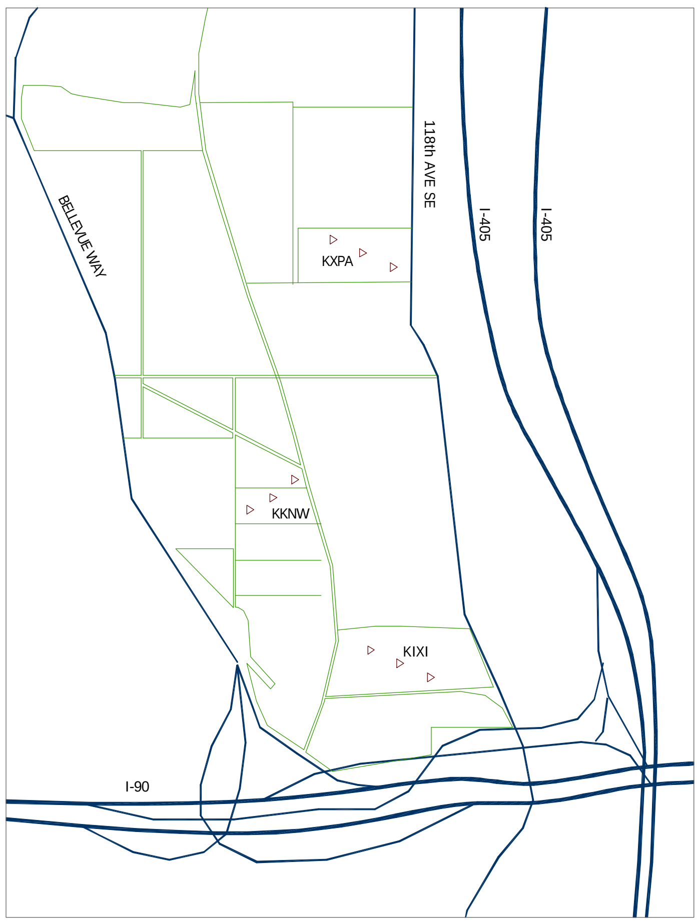
Consolidation of these facilities at one site is possible, however a new facility would have to provide a coverage improvement for KIXI and KKNW in order to make it worthwhile to commit the resources. It is conceivable that the cost for a project of this magnitude could approach 5 million dollars.

Any proposed site move for these transmitting facilities would need to be within 5 miles (8 km) of the existing sites. The only realistic areas that could be considered for a medium wave radio station sites are existing park areas such as Kelsey Park off Richards Road and the Lake Hills Connector or the Lake Hills Greenbelt. These areas will have similar if not greater neighborhood and political problems than those of Mercer Slough. All other suitable areas that are within an acceptable search area are developed.

It is important that the site have vehicle access so that equipment can be loaded and unloaded from a truck into a transmitter building and so that the generator can be fueled. Also, it is very important that all of these facilities have access for emergency vehicles, both fire and medical aid. The transmitter sites should be maintained so that all parts of the antenna system remain free from brush and other vegetation. These towers need to be inspected regularly by a Registered Professional Engineer who is qualified to render opinions on guyed communications towers.

Introduction

AM[1] or more properly Medium Wave (MW)[2] radio station antennas and transmitting sites located in Mercer Slough were first established in the slough in the early 1960's. The purpose of this report is to provide the background information about why this area was chosen for these facilities in order to assist the City of Bellevue in management of the property leases and to develop guidelines and procedures for the maintenance practices necessary to allow the tenants to properly operate the facilities.



Mercer Slough Area

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[1] "AM" is the abbreviation for Amplitude Modulation which is used in the US on the standard broadcast band from 530 kHz to 1700 kHz.

[2] "Medium Wave" includes the frequencies from 300 kHz to 3 MHz. Hz is the abbreviated form of hertz in (cycles per second), kHz is for kilohertz or 1,000 Hz, and MHz is megahertz or 1,000,000 Hz.

The current facilities for the stations in Mercer Slough are as follows:

Station[3]	Daytime	Nighttime	Land Parcel Number
KIXI 880 kHz	50 kW Directional Antenna	10 kW Directional Antenna	0924059063
KKNW 1150 kHz	10 kW Non-Directional Antenna	6 kW Directional Antenna	7000100120 7000100130
KXPA 1540 kHz	5 kW Non-Directional Antenna	5 kW Directional Antenna	0424059042

Station Contact Information

Station	Owner	Contact[4]
KIXI 880 kHz	Sandusky Radio	George Bisso, Chief Engineer, 425-373-5516 Marc Kay, General Manager, 425-454-1540 3650 131st Avenue SE, Suite 550, Bellevue
KKNW 1150 kHz		
KXPA 1540 kHz	Multicultural Broadcasting	Mike Gilbert, Chief Engineer, 360-371-5500 Lisa Shepherd, General Manager, 206-292-7800 1100 Olive Way, Suite 950, Seattle

History

The area of the Mercer Slough is topographically a low lying area of exposed peat that was uncovered in 1916 when the level of Lake Washington was lowered by 9 feet by the opening of the ship canal from Lake Washington to Lake Union. Various portions of the Slough have been used for agricultural purposed over the years. The primarily use has been for berry farms on the west side of the Slough. The area has been transformed into park lands and open space largely because it was unsuitable for other uses. MW radio facilities are quite compatible with wetlands and bogs as these areas are ideal for MW radio propagation, but can retain the wetland vegetation

[3] Station formats and ratings area shown in Appendix B. The current formats are: KIXI - Adult Standard, KKNW - News Talk and Sports, and KXPA - Spanish Language and other ethnic block programming.

[4] This information is current as of November 2002. Radio stations are bought and sold and radio station personnel change. If you have trouble contacting the station please call Hatfield & Dawson for help.

and wildlife. Typically these areas are disturbed for one season of construction and then allowed to remain fallow. The only vegetation maintenance that is needed is in a small area around the towers and buildings.

The history of Mercer Slough as a radio transmitter site begins with a legal reference. In the 1962 case “Ex rel Pruzan vs. Redman,” 60 Wash. 2d 521, 374 P.2d 1002, the Washington State Supreme Court determined that the antenna/transmitter system of a broadcasting station should be considered as a “public utility” use, and this led to land use approval for the location of the KUDY (eventually KIXI, or “K-91" in Roman numerals!) antenna system at the southeastern part of the Slough area, just north of the then U.S. Highway 10 right of way, an area zoned agricultural by King County.

The KIXI site was constructed and placed into operation in 1962. The antenna employs three uniform cross section guyed towers which are each 240 feet in height. The towers were originally arranged in a straight line roughly east-west, spaced about 270 feet apart. The equipment building was constructed just west of SE 118th (originally Lake Washington Boulevard), with the feed and control cables to the antenna towers and a boardwalk walkway extending into the marshy area around the towers, and a radial ground system of 120 wires of 270 feet in length laid on the “surface” of the bog or swamp.

In the late 1960's after U.S. 10 had been transformed into I-90 and additional support piers and fill were added to support additional traffic lanes, the heavy loading of the fill and construction material began to deform the peat underlayment of the lower portion of the Slough. This deformation eventually resulted in movement of the KIXI towers, which were constructed on long piling foundations. The movement stabilized in the early 1970's, leaving the towers in an offset configuration, no longer in a straight line. As a result, the KIXI antenna radiation pattern was required to be modified to accommodate the new geometry and relicensed by the FCC. This work was completed in 1972, including some new ground system connections. The original system was found to be essentially intact, although moved in part by the same changes that moved the tower(s).

Mercer Slough - View from the south

A second antenna system was constructed in Mercer Slough around 1967, also on the east side just west of SE 118th, about 1 kilometer (0.6 mile) north of the KIXI antenna. This antenna system was for a new radio station whose original call letters were KBVU, and which was licensed to Bellevue, operating on 1540 kHz. The antenna employed two uniform cross section towers which are 160 feet in height and on a roughly east-west line separated by 160 feet. The equipment building was located west of SE 118th and the antenna feed and control cables routed similarly to the KIXI system. This station operated for only a short period of time before it encountered serious financial difficulty and ceased operation. After a period of a couple of years the license and equipment were purchased by Kemper Freeman, Sr., who was at that time the owner of KFKF(AM) and (FM). When he commenced operation of the 1540 station he was required by the multiple ownership rules of the time to give up the license for the original KFKF(AM), which had operated on 1330 kHz. Freeman eventually sold the station to a group headed by Stuart Ballinger, who in 1974 implemented a power increase for the station, which required construction of an additional tower essentially identical to the first two, located on the same axis an additional 160 feet to the west. The ground system for this revision was constructed and at the same time the original system was determined to be virtually nonexistent. As a consequence a complete new system was constructed, consisting of 120 equally spaced radial wires around each tower to a distance of 160 feet, laid on the surface of the ground or the detritus layer of humus.

In the early 1980's the third antenna system at Mercer Slough was constructed. This system, for KAYO, 1150 kHz (now KKNW) was constructed on the west side of the slough, roughly 0.5 km or 0.3 miles NW of the KIXI towers. It also employs three towers, but they are arranged in an offset configuration (known to engineers as a “dogleg”), with the end towers separated by 200 feet, with one tower NE of the center tower and the other one roughly west of the center tower. Like the KIXI and the 1540 kHz antenna system, it has a system of “barely buried” ground radials and a walkway and cable system on the surface. The radials for this antenna system extend for 215 feet. This antenna was originally intended to be located somewhat further north, but land availability and cost issues resulted in the use of the present location.

Two other changes have occurred to the transmitting systems which did not involve any changes in the physical arrangements or configuration of the antenna towers. KIXI in 1983 changed frequency from 910 kHz to 880 kHz, and was authorized to increase its power, in two steps, to 50 kilowatts (kW)[5] daytime and 10 kW nighttime. KKNW, the 1150 kHz station, has also made a power increase, from 5 kW to 10 kW daytime and to 6 kW nighttime.

[5] 1 kW = 1000 Watts

Each of the three antenna systems is a very specific purpose-built design, optimized for the original frequency, power, and allocation conditions. The modifications to each station's operation over the years have not required physical modification of the original antenna tower configuration. Even the most drastic of the changes, those undertaken for the power increase of the 1540 kHz station, required only an additional tower but no modification of the original ones.

Site Selection and Radio Engineering Basics

Before a discussion of any of the issues dealing with a MW radio station's site location, power, coverage or facility options, it is important to understand some of the basic concepts of radio propagation, radio physics, and Federal Communications Commission regulations. Medium Wave radio is different from VHF[6] radio (FM and TV). FM and TV signals travel (propagate) using line-of sight paths. This propagation method necessitates that these VHF antennas be placed on elevated locations. In the Puget Sound region these stations are located on towers at West Tiger Mountain, Cougar Mountain, Queen Anne and Capitol Hill. All of these locations have antennas with elevations greater than 950 feet above mean sea level to provide line-of sight service to radio receivers.

MW Radio Propagation

Unlike VHF radio, MW radio signals propagate differently during daytime and nighttime hours. Local MW signals travel by means of "groundwave" propagation. The signal strength and distance traveled in a given direction are directly dependent upon the electrical conductivity[7] of the soil along that path; higher conductivity soil allows the signal to travel farther.

After sundown, MW signals also travel using "skywave" propagation. Skywaves are radio waves that are reflected back to Earth by the ionosphere, and thus can travel much farther than do groundwaves. The ionosphere is the upper region of the earth's atmosphere, located approximately 30 to 250 miles above the surface of the earth. Sunlight changes the physical

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[6] VHF is Very High Frequencies from 30 to 300 MHz.

[7] Electrical Conductivity is measured in Siemens (S or 1/1000 Siemens = mS), which is the inverse of Electrical Resistance measured in Ohms (Ω).

properties of the ionosphere. During daytime the signals are absorbed by the ionosphere, but at nighttime the signals are reflected back to earth.

Tuning through the MW band at nighttime it is possible to experience Skywave propagation. There are a number of radio stations from locations far away that can be received in this area. In particular, there are several San Francisco Bay area stations that have good coverage up and down the coast during nighttime hours. A good example of this phenomenon is radio station KFBK, which operates on 1530 kHz in Sacramento, CA. KFBK cannot be received in the Puget Sound area during the daytime but at nighttime it is received quite well. The propagation change between daytime and nighttime often requires the use of different antenna configurations or power levels during daytime and nighttime, in order to minimize interference[8] to other stations. Most stations use additional towers to reduce skywave interference, which affects the size of property needed for an antenna system.

For the best performance for groundwave propagation, it is important to choose a site that is in an area of good ground conductivity. Higher conductivity surface material will allow the MW signal to travel farther. Various surface material types are better conductors than others depending upon the electrical make-up of the material and its ability to retain water. For example, river bottom soil (silt) is a better conductor than gravel (glacial till & hardpan), due to silt's ability to retain water. Glacial hardpan, which is found in most upland areas of the Puget Sound region, has very low conductivity. MW antenna sites located near a hill with glacial hardpan or on a site with glacial hardpan perform very poorly. Broadcasters prefer the highest conductivity soil available, which is why the overwhelming majority of MW stations and all major MW stations in the Puget Sound region are located within 2000 feet of the Sound or river bottom environments.

Table 1 illustrates a basic list of surface material composition (soil and water) ranked by their ability to conduct MW signals. Second to salt-water, river bottom is the best type of soil in the Puget

[8] Interference is defined as unwanted signals degrading the performance of reception of a desired signal. Interference can be from several sources. These include: co-channel interference which is a signal broadcast on the same channel as the desired signal; adjacent channel interference which is a signal broadcast on a nearby channel; electrical noise which is static that can come from electrical sources (hair dryer and other electrical motors, power lines, etc.) and blanketing interference which can be caused by strong radio or TV signals.

Sound region. This practice has been established for at least 60 years in the location of MW transmitting facilities. The following is a quote from the *Standards of Good Engineering Practice Concerning Standard Broadcast Stations (550-1600 kc.) 1939*[9].

> *"The ideal location of a broadcast transmitter is in a low area of marshy or "crawfishy" soil or area, which is damp the maximum percentage of time and from which a clear view over the entire center of population may be had…*
>
> *The type and condition of the soil or earth immediately around a site is very important. Important, to an equal extent, is the soil or earth between the site and the principal area to be served. Sandy soil is considered the worst type, with glacial deposits and mineral-ore areas next. Alluvial, marshy areas and salt-water bogs have been found to have the least absorption of the signal."*

Meeting these criteria is critical when attempting to maintain City-of-License coverage from a distant transmitter site. Appendix B includes a list of MW Transmitter Sites in Western Washington.

[9] Federal Communications Commission, *Standards of Good Engineering Practice Concerning Standard Broadcast Stations (550-1600 kc.) 1939*. United States Government Printing Office Washington: 1944, Page 33. This advisory information was added in whole as part of the FCC rules in 1956 and portions of this document were incorporated into the FCC rules in the mid 1980s as part of streamlining of the Federal rules.

Comparison of Conductivity and Surface Material Composition[10]

Surface Material Composition	Conductivity
Sea Water	5000 mS/m
Pastoral Land, Rich Soils, River Bottoms, Low Hills	30 mS/m – 10 mS/m
Pastoral Land, Densely Wooded	8 mS/m – 2 mS/m
Pastoral Land, Medium Hills, Medium Forestation, Clay Soil	6 mS/ m – 1 mS/m
Rocky Soil, Steep Hills, Sandy Soil	2 mS/m – 0.1 mS/m
City Industrial Areas – Average Attenuation	1 mS/m
City Industrial Areas – Maximum Attenuation	0.1 mS/m

Table 1

Ground conductivity measurements were compiled into a map titled *Estimated Effective Ground Conductivity in the United States Figure R3* (revised to figure M3) by the FCC. This map is used for the allocations planning for the placement of MW stations in the United States. This map presents optimistic ground conductivities and is used when measured conductivity is not available. According to this map, Western Washington has only two conductivity zones, whereas we know from our experience in the area that there are many more. However, this map serves its purpose for planning the placement of MW stations. This information has been used and accepted since it was compiled in 1954.[11]

Radio Physics Terms

MW radio signal strengths are measured in Volts per meter (V/m)[12]. The FCC requires that MW radio stations provide a predicted 5 mV/m daytime signal and a 5 mV/m nighttime signal or a Nighttime Interference Free (NIF) signal, whichever is greater, over the city of license.

[10] Adapted from Federal Communications Commission, *Standards of Good Engineering Practice Concerning Standard Broadcast Stations (550-1600 kc.) 1939.* United States Government Printing Office Washington: 1944, Table B

[11] Effective Radio Ground-Conductivity Measurements in the United States, National Bureau of Standards Circular 546, February 26 1954

[12] 1 mV/m (millivolts per meter) = 0.001 V/m and 1 µV/m (microvolts per meter) = 0.000,001 V/m

Station	Nighttime Interference Free Signal (mV/m)	City of License
KIXI 880 kHz	12.3 mV/m	Mercer Island - Seattle
KKNW 1150 kHz	3.2 mV/m (5.0 mV/m)	Seattle
KXPA 1540 kHz	7.8 mV/m	Seattle

MW radio receivers vary greatly in sensitivity and much has been written lately about the poor performance of MW receivers built today. The general practice for broadcaster use for coverage is 2 mV/m for coverage in vehicles, 5 mV/m to 25 mV/m for in home and 25 mV/m in downtown office buildings. On a Walkman-type portable radio, you may need as much as 5 millivolts (5 mV/m) of signal to have static-free reception[13]. The reason for these recommended signal levels is to overcome the effects of interference. Sources of interference include fluorescent lights, computers, TVs, office equipment, overhead power lines, and other appliances operating near a radio that can overload the receiver. In a city core, stations generally need more signal than this because of heavy attenuation inside large steel structures like office buildings. In your home, depending on the location, type of radio, and the utilization of any external antennas, you can have good reception with signals between 1 mV/m and 25 mV/m.

Power is measured in Watts. The transmitter output power for a MW radio station is typically from 1 to 50 kW. In the United States the maximum operating power for MW radio stations is 50 kW. In the Puget Sound area KOMO 1000 kHz, KIRO 710 kHz, KYCW 1090 kHz, and KJR 950 kHz are currently the only MW radio stations licensed to operate full time at this power. The powers for the radio stations in Mercer Slough are KIXI 50 kW daytime and 10 kW nighttime; KKNW 10 kW Daytime and 6 kW nighttime; and KXPA 5 kW daytime and nighttime.

[13] International Telecommunication Union Recommendation 415-2, Type A Receivers, ITU-R, Volume 1997 BS Series

Antenna Theory

MW antenna heights are referenced to a wavelength[14] (this only includes the radiating portion of the tower). In MW broadcasting, 5/8 wavelength (or 225°) antennas are more efficient than ¼ wave antennas. A ¼ wavelength (or 90°) antenna is near the lower end of acceptable antenna heights. Antenna heights much below 1/4 wavelength are undesirable, as efficiencies decrease dramatically below this height. A 225° antenna provides the maximum coverage and is the theoretical maximum. The efficiency decreases for antennas taller than 225°, which results in reduced coverage. In summary, taller towers are more efficient and shorter towers decrease coverage and are more difficult to work with. Table 2 summarizes the heights and efficiencies of the Mercer Slough MW stations:

Comparison of Antenna Heights and Electrical Efficiency

Station	Tower Height (feet)	Tower Height (meters)	Tower Height (electrical degrees)	Efficiency (mV/m at 1 km for 1 kW)
KIXI 880 kHz	240 feet	73.2 meters	77.3°	297.7 mV/m
KKNW 1150 kHz	240 feet	73.2 meters	101.0°	312.7 mV/m
KXPA 1540 kHz	160 feet	48.7 meters	90.0°	305.8 mV/m

Table 2

The additional height of the antenna adds field strength, which also adds significantly to the coverage area.

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14 Wavelength or λ is determined by the following formula: $\lambda = c/f$ where f is frequency in Hz and c is the speed of light in meters per second (299,792,458 m/s). A full wavelength for KIXI operating at 880 kHz is $\lambda = 340.1$ m or 1117.7 ft. Antenna heights (and other antenna dimensions) are also expressed in electrical degrees where $\lambda = 360°$ and $¼\lambda = 90°$.

FCC Rules

The Federal Communications Commission (FCC) regulates non-federal use of radio spectrum. A MW radio station's location, frequency and power are controlled by federal rules. The FCC Rules (along with international treaties relating to use of the spectrum) have been developed over the last 65 years and are designed to provide public service while minimizing interference to and from other broadcast facilities. The rules are codified in Part 47 of the Code of Federal Regulations.

MW radio stations are allocated on an interference limited basis and are far more difficult to site than FM, TV, Land Mobile or Cellular. All new facilities or changed facilities must protect the coverage of all existing radio stations using the methods described in the FCC rules. The FCC requires that radio stations provide radio coverage to their community of license. KIXI is licensed to Mercer Island and Seattle, KKNW is licensed to Seattle and KXPA is licensed to Bellevue. The *Standards of Good Engineering Practice* recommends 25 to 50 mV/m over business or factory areas of the community of license[15]. This was one important factor in location of these facilities in Mercer Slough.

At nighttime some MW stations (including all three of these stations) must use a directional antenna to reduce potential interference to other stations on or near the same channel because of skywave propagation. This is an antenna system that produces more power in some directions and reduces the power in other directions. An understandable analogy for directional antennas is a floodlight. A floodlight puts a lot of light in one direction but behind it there is very little light. Directional antenna systems at MW frequencies require the use of multiple towers. In MW antennas, the tower itself is the antenna element[16], whereas, at higher frequencies, (VHF – FM, TV, etc.) the antenna element is mounted to or suspended from the tower or towers. The majority of MW radio stations in this area use directional antennas. KOMO, 1000 kHz (3 towers); KIRO, 710 kHz (2 towers); KJR, 950 kHz (5 towers); and KNWX, 770 kHz (3 towers), all use directional antenna systems to satisfy their interference and coverage requirements.

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[15] Federal Communications Commission, *Standards of Good Engineering Practice Concerning Standard Broadcast Stations (550-1600 kc.) 1939.* United States Government Printing Office Washington: 1944. Page 35.

[16] The antenna element is the part of the antenna in which electrical current is flowing.

The FCC required nighttime protection limits for KIXI, KKNW and KXPA are in Appendix D. The FCC rules have been modified substantially since these stations were licensed. These rule changes allow for operation at greater power during both daytime and nighttime than when they were originally located in Mercer Slough.

Land Area Requirements

The FCC interference calculations are used to develop the directional antenna design. The size of the directional antenna determines the area of land required. The towers have to be arranged in a particular mathematical relationship to make a directional antenna, and are often spaced several hundred feet apart. KIXI, KKNW and KXPA all require enough land for a minimum of 3 tower arrays.

Ground System

A new antenna site ideally requires bare earth, and preferably, it must be as flat as possible. Part of the antenna system is a ground system that is buried between 10” and 24" deep in the ground out to ¼ wavelength away from the base of each tower. For KIXI this is 280 feet, for KKNW this is 215 feet and for KXPA this is 160 feet. A wooded site, depending on the number of trees, would need to be clear-cut and some under brush removed. See Appendix E “*Eight Drawings Showing the Installation of a Standard Broadcast Ground System*” for typical MW ground system configuration and installation practices.

Blanketing Contours

Another provision in the Code of Federal Regulations requires that radio stations locate their transmitter in areas of low population density. 47 CFR 73.24 (g) requires:

> *That the population within the 1 V/m contour does not exceed 1.0 percent of the population within the 25 mV/m contour: provided, however, that where the number of persons within the 1 V/m contour is 300 or less the provisions of this subparagraph are not applicable.*

The FCC regulations encourage transmitter sites to be located in low population density areas to minimize any potential interference that may be received by people living near the transmitter site. The area around Mercer Slough has had MW radio stations for 40 years and the radio stations have worked with the population nearby to solve the blanketing problems. The FCC requires that new facilities solve blanketing interference for the first year of operation. The rule 47CFR 74.318 reads:

> *(b) After January 1, 1985, permittees or licensees who either (1) commence program tests, or (2) replace their antennas, or (3) request facilities modifications and are issued a new construction permit must satisfy all complaints of blanketing interference which are received by the station during a one year period. The period begins with the commencement of program tests, or commencement of programming utilizing the new antenna. Resolution of complaints shall be at no cost to the complainant. These requirements specifically do not include interference complaints resulting from malfunctioning or mistuned receivers, improperly installed antenna systems, or the use of high gain antennas or antenna booster amplifiers. Mobile receivers and non-RF devices such as tape recorders or hi-fi amplifiers (phonographs) are also excluded.*
>
> *(c) A permittee collocating with one or more existing stations and beginning program tests on or after January 1, 1985, must assume full financial responsibility for remedying new complaints of blanketing interference for a period of one year. Two or more permittees that concurrently collocate on or after January 1, 1985, shall assume shared responsibility for remedying blanketing complaints within the blanketing area unless an offending station can be readily determined and then that station shall assume full financial responsibility.*
>
> *(d) Following the one year period of full financial obligation to satisfy blanketing complaints, licensees shall provide technical information or assistance to complainants on remedies for blanketing interference.*

So any change in the existing facilities would open the stations to the liability and financial obligation to repair the equipment of the effected neighbors.

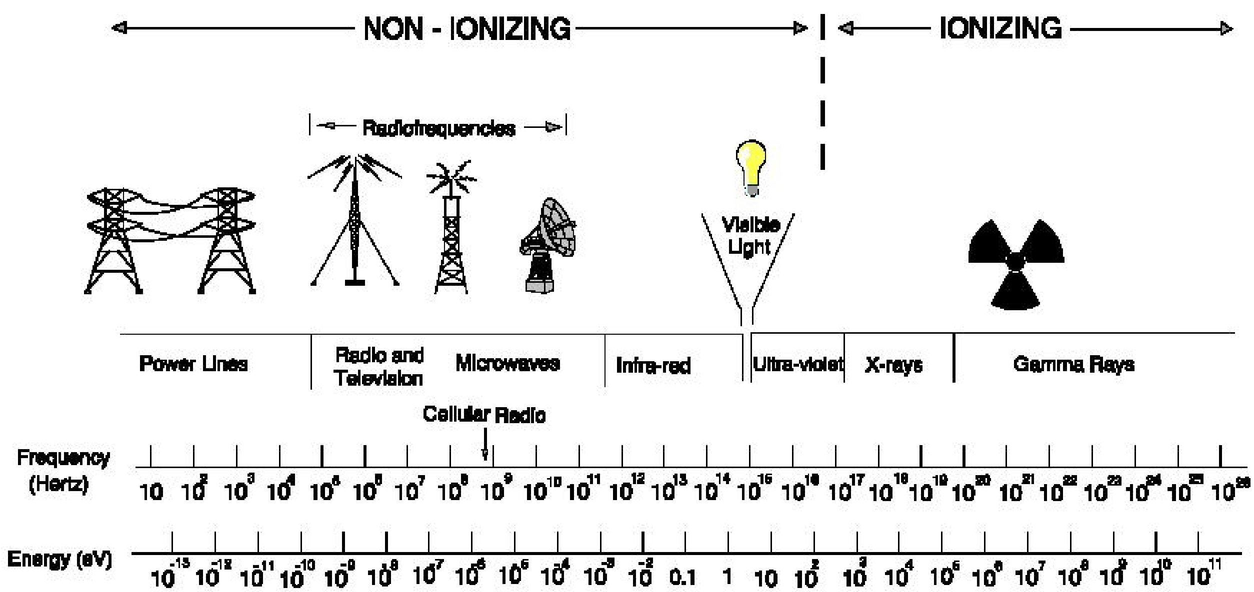
Human Exposure to Radio Frequency Energy

The FCC Maximum Permissible Exposure (MPE) for radiofrequency fields outlined in *47 C.F.R §1.1310 Radiofrequency radiation exposure limits* was developed as a result of the 1996 Telecommunications Act. Congress required the FCC to adopt guidelines and methods for evaluating the environmental effects of radiofrequency exposure. The FCC based these guidelines on the RF safety standards developed by the Institute of Electrical and Electronics Engineers (IEEE), which were adopted by the American National Standards Institute (ANSI), and the National Council on Radiation Protection and Measurements (NCRP). Specifically, the reports *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz* ANSI/IEEE C95.1-1992 and *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields*, NCRP Report No. 86 1986. The FCC rule process invited recommendations in the form of comments from the public and other interested parties. These parties included governmental agencies such the U.S. Environmental Protection Agency (EPA), National Institute for Occupational Safety and Health (NOSH), individual researchers and institutions and industrial interests. The FCC guidelines in essence are comprised of the more restrictive aspect of both the ANSI/IEEE and NCRP recommendations.

The IEEE developed their exposure standard by following a rigorous scientific process. The committees for the IEEE are made up of volunteers from government , research and industry who serve without compensation. This standard represents a consensus of the broad expertise of those committee members. The members of the committee reviewed all available scientific research literature on this subject. The literature showing radiofrequency exposure risks to humans was reviewed for engineering, biological and statistical validity. The evaluation of the literature identified an exposure threshold for unfavorable biological effects in humans. A safety factor of 10 was applied to this exposure threshold for workers and an additional safety factor of 5 was applied for general public.

The NCRP is a nonprofit corporation chartered by Congress to collect, analyze, develop and disseminate information and recommendation on exposure to both ionizing and non-ionizing radiation. The NCRP also based its recommendations on a review of the scientific literature for exposure to humans.

It is important to understand the distinctions between ionizing and non-ionizing radiation. Radiofrequency fields are non-ionizing electromagnetic radiation. Ionizing radiation, such as that associated with nuclear power, contains enough energy to physically change chemical bonds and



The Electromagnetic Spectrum

the electron rings of atomic structures. The following graph shows the electromagnetic spectrum. The publicly accessible areas around the MW stations in Mercer Slough are well below the FCC MPE guidelines. The only area that exceed the MPE are within 8 feet of the tower bases. These areas are fenced and posted with the appropriate warning signs[17].

[17] For more information see FCC Office of Engineering & Technology Bulletin 65 "*Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*" www.fcc.gov/oet/info/documents/bulletins/

FAA Airspace Considerations

The FCC along with the FAA requires all towers over 200 feet above ground level to be painted orange and white and lighted with strobe lights or flashing red aircraft beacon lights. The KIXI and KKNW towers are 240 feet above ground level and are not painted or lighted, by waiver of the FAA recommendations. The requirement for lighting on the KKNW towers was also waived by the FAA. This waiver was likely allowed due to the elevation of the surrounding terrain being much higher that tower tops. The air space study number is 80-AWN-194-OE. The KIXI waiver is sufficiently antique that the original documentation is not easily recovered.

Co-Location Considerations

MW radio stations can be co-located. This typically can be done if the stations are sufficiently spaced in frequency (greater than 200 kHz). All of these stations could be located on one directional facility. However, there are compromises in coverage due to constraints in the directional antenna configuration. The feasibility of co-location for the stations in Mercer Slough is addressed later in this report.

Site Access

Site access is another crucial element of a MW antenna site. A site has to have access for continued facility maintenance. It is important that the site have vehicle access so that equipment can be loaded and unloaded from a truck into a transmitter building and so that the generator can be fueled. Also, it is very important that all of these facilities have access for emergency vehicles, both fire and medical aid. There continues to be a number of transmitter fires around the country every year and there has been one transmitter fire within the last ten years at KIXI. Access to aid for a injured worker is a priority, as transmitter site work is inherently dangerous as there is work around high voltage and occasional maintenance work that requires climbing the towers.

Power and Telephone

Any site considerations must include three phase electrical power and telephone access. Three phase power is required to operate transmitters. The audio program information is fed to these sites using telephone circuits. All of the existing sites have these facilities.

Coverage Requirements and FCC Allocations Considerations

FCC Daytime Allocation Rules

The daytime signals for MW stations are limited by interference circumstances to other stations operating on the same channel, first adjacent channel, second adjacent channel, and third adjacent channel. These stations are not allowed to have overlapping signal levels that the FCC has determined causes interference (47 CFR 73.182). The chart below is a summary of the daytime requirements:

Frequency Separation	Proposed Station	Contour of Other Stations
0 kHz (co-channel)	0.005 mV/m 0.025 mV/m 0.500 mV/m	0.100 mV/m (Class A) 0.500 mV/m (Class B & C) 0.025 mV/m (all classes)
10 kHz (1st adjacent channel)	0.250 mV/m 0.500 mV/m	0.500 mV/m (all classes) 0.250 mV/m (all classes)
20 kHz (2nd adjacent channel)	5.0 mV/m	5.0 mV/m (all classes)
30 kHz (3rd adjacent channel)	25 mV/m	25 mV/m (all classes)

These daytime contours are based on calculated or measured coverage

FCC Nighttime Allocation Rules

The 1992 FCC rules for nighttime allocation studies are based on nighttime skywave interference calculations to the sites of co-channel and domestic first adjacent channel stations. These interference levels are combined using Root Sum Squared (RSS) calculations to provide an interference level for each station. The directional antenna radiation limits are based on the RSS calculations which are made to the other co-channel and first adjacent channel stations. If the station's contribution to other domestic station's RSS is greater that 50 % it is required to reduce the interference level by 10 %. If the station's contribution to the other station's RSS is greater that 25 % and less than 50 % that the interference level can remain the same. For a station that does not contribute to the RSS calculation the interference level can increase up to 25 %.

There are also considerations for Class A stations. Class A stations are the old "Clear Channel" stations that were licensed in the 1920s through the late 1930s. Many of these stations operate using non-directional antennas with 50 kW daytime and nighttime. The service of these stations are protected. Both daytime and nighttime coverage is protected to the 0.5 mV/m. This means that if a Class B station (such as all the stations in Mercer Slough) wants to make a change in facilities is can not produce a signal that is greater that 1/20 of the protected service level of a domestic or international co-channel Class A station, and ½ that of a domestic first adjacent channel Class A channel station.

Using these rules and the database of stations in the entire western hemisphere a set of daytime and nighttime signal limits are developed. These limits along with the desired coverage area are used to develop the directional antenna patterns. The nighttime limits for the Mercer Slough stations are shown in Appendix D.

Any changes to the Mercer Slough stations must result in an increase in population coverage or an increase in the density of the signal over a desired coverage area. This is a requirement to get the current owners of the stations to cooperate with any proposed improvements. The existing coverage area of these stations are shown in Appendix A.

Site Consolidation Options for Mercer Slough

It is possible to combine the transmitting facilities on one set of antennas. To combine the facilities the frequency separation between the stations needs to be greater than 200 kHz and the orientation of the towers needs to be compatible with the directional antenna requirements of each station. Combined facilities require the addition of filtering to keep the stations from interacting.

It is possible for KXPA and KIXI to combine facilities. KXPA's existing facilities can essentially be replicated using the KIXI tower placement. This would require larger buildings to be constructed at the tower bases and a larger transmitter building. If there is any construction at the KIXI tower site it would be prudent to upgrade the foundations of all of the towers, guy anchors and buildings. A first order cost estimate for this consolidation would be around $800,000 depending on the amount of foundation upgrades. This option would also require a sublease that is acceptable between the owners of KIXI and KXPA.

One other possibility is consolidating all of the facilities at one location, such as the KIXI site. While a specific design has not been done and is beyond the scope of this report, a consolidation like this would most likely require two additional towers to be constructed. This would also include a building that could house the transmitters with additional facilities at the tower bases. This new facility would have to provide a coverage improvement for KIXI and KKNW in order to make it worthwhile to commit the resources to this consolidation. It is conceivable that the cost for a project of this magnitude could approach 5 million dollars.

Alternative Sites

Any proposed site move would need to be within 5 miles (8 km) of the existing sites for these stations. This is because of the nighttime antenna patterns that direct all of the energy westward. An acceptable site must have all of the following:

good ground conductivity around the site
relatively flat land
10 acres or more
few neighbors nearby
power and telephone available
ability to put up minimum of 240' towers

Any site to the east would have problems with the poor conductivity along the ridge lines in this area. Multiple test transmitter measurements made in the Snohomish Valley, near Carnation, clearly show the extremely poor conductivity to the west, over the populated areas. Any sites too far north or south would have trouble covering the city of Seattle at nighttime. The only realistic areas that could be considered for MW radio station sites are existing park areas such as Kelsey Park off Richards Road and the Lake Hills Connector, or the Lake Hills Greenbelt. These areas will have similar if not greater neighborhood and political problems than those of Mercer Slough. All other suitable areas that are within an acceptable search area are developed.

Maintenance Recommendations

MW facilities require regular maintenance to operate trouble free. The biggest maintenance problem in Mercer Slough is vegetation growth. It is important that all parts of the antenna system remain free from brush and other vegetation. Vegetation can restrict access to important parts of the system. The biggest problem is vegetation shorting across the base insulator which can cause the station to go off the air or, in the worst case, cause the vegetation to burn and start a brush fire. In Mercer Slough this is in the form of trees growing into the tower or of blackberry vines overtaking the base insulator or guy lines. Both of these problems have caused the stations to go off the air. The brush should be cleared from around and under the tower bases, guy lines, guy foundations and walkway.

The fencing around the tower bases is required to be maintained to minimize any shock and burn hazard from the tower base. The FCC rules require access to the tower bases and fencing. 47 CFR 73.49 requires:

> *AM transmission system fencing requirements. - Antenna towers having radio frequency potential at the base (series fed, folded unipole, and insulated base antennas) must be enclosed within effective locked fences or other enclosures. Ready access must be provided to each antenna tower base for meter reading and maintenance purposes at all times. However, individual tower fences need not be installed if the towers are contained within a protective property fence.*

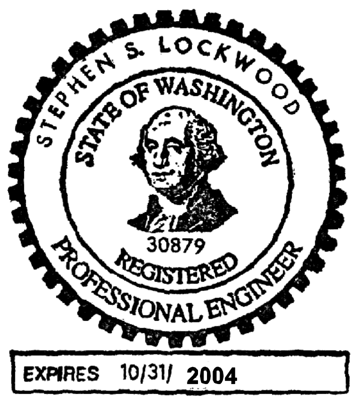
These towers, particularly the KIXI towers due to their floating foundations, need to be inspected regularly by a Registered Professional Engineer who is qualified to render opinions on guyed communications towers. The guy lines and guy foundations have to be inspected on a regular basis to assure they are in good condition. Frequently the towers need to have the guy lines re-tensioned. Also, all foundations, fencing, buildings, and walkways should be inspected on a quarterly basis and all problems noted and repaired.

Statement of Engineer

I am an experienced radio engineer whose qualifications are a matter of record with the Federal Communications Commission. I am a partner in the firm of Hatfield & Dawson Consulting Engineers, am registered as a Professional Engineer in the States of Washington and Alaska and hold an FCC General Radiotelephone Operator License, number PG-10-14799.

18 November 2002

Stephen S. Lockwood, P.E.



Appendix A

Coverage Maps

Appendix B

MW Transmitter Sites in Western Washington

and Radio Formats and Ratings

Appendix C

Parks Department Air Photo of Mercer Slough

Appendix D

Allocation Studies for KIXI, KKNW and KXPA

Appendix E

Eight Drawings Showing the Installation of a Standard Broadcast Ground System

Appendix F

Historical Information From Land Use Files and Other Sources