Rules of Thumb for Ground Radials

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I installed KAHU [1060 Khz. AM] in Hilo [Big Island] over 15 years ago. Its ground system was installed by hand, pick and shovel. Five miles of #10 solid copper wire installed as 120 radials, covering 5 acres.

The result was one of the more efficient BC stations in Hawaii, especially on this island. The FCC wanted the station to lower the power from the 1 kW specified in the construction permit to 938 watts. The measured 190 mV/meter at one mile exceeded the expected 175 mV/m.

When I reminded the FCC about the poor ground conductivity in Hawaii, they said "OK" to the 1 kW. My measurements showed that the average ground conductivity 0-20 miles from Hilo to be less than 1 mmhos/m (not including sea water paths).

Fortunately, one can cheat on this and suffer only minor loses, up to a point. Backing off from 120 to 60 radials is not a big deal. Trying to get by with only four ground radials is certainly going to have a big negative impact on your antenna performance.

There are indications that four ground laid radials detune an antenna greatly and make for six DB of power loss. Four elevated radials will work well if properly installed. 16 ground laid radials clear up many of the problems seen with four ground laid radials based on modeling.

Here are rules that seem to be reasonable for ground radials (not to be confused with elevated resonant ground plane systems):

1. Radials can be rather small diameter wire since so many of them exist to share the return currents and they are in parallel with the ground currents in the earth as well. Each radial is going to carry very little RF current.
2. Ground radials need not be resonant. This is a misconception based on elevated or ground plane type elements. True ground laid radials designed to supplement ground return currents in the earth need not be resonant. They are different from the elevated ground plane radials in this regard since ground radials supplement ground currents and do not try to replace them entirely. Elevated ground plane radials, especially if few in number, need to be bit longer than 1/4 wave at the operating frequency.
3. Ground radials seldom need to be longer than .2 (two tenths) wavelength regardless of the height of the antenna, even a half wave vertical radiator. A maximum of .28 wavelength seems to certainly be an upper limit for ground radial length. Due to detuning of the ground, insulated wires laid on the ground tend to be electrically 1/4 wavelength when the physical length is close to .28 wavelength.

4. Ground radials do not need to be much longer than the antenna is tall. A shortened antenna with loading coils will have a more compact "near field" where the majority of the antenna field is. The ground needs only reach out as far as the near field extends. Field intensity drops off with the square of the distance from the base of the antenna.
5. Minimum number of ground radials is probably 8, closer to 16, well you would do better with 32. You get the idea - the more the merrier. Four ground radials is going to be a horrible system. More than 32 radials gets you into the area of diminishing returns.

The ground around a vertical monopole type antenna can be viewed as strings of series connected resistors fanning out from the base. The purpose of the radials can be viewed as attempting to short circuit as many of these resistors near the base as possible. This is especially critical very close to the base where RF field density is highest, and its importance drops off quickly beyond 1/8th wavelength from the base of any vertical antenna, where the RF field density per unit area goes down sharply.

It is important not to confuse this application with elevated ground planes. We are talking about radials that supplement the return of ground currents to the base of the antenna, especially in the near field. They work "in parallel" with the existing earth ground surface to supplement it.

Elevated radials are a resonant element and serve a decoupling function and establish a completely artificial ground. They should be resonant, quarter wave wires, but still in fair numbers, probably more than the four usually seen, for best results.

Efficiency	Decibels	Radials	Wavelength
90%	- .457	120	0.40
80%	- .969	45	0.24
70%	-1.54	22	0.16
60%	-2.21	7	0.06
50%	-3.01	4	0.03

Source: StepperIR