Electron beam use for modern conformal therapy has not been thoroughly investigated due to many factors, including the lack of beam penetration of low energy electrons, collimation and shaping systems, limitations in dose calculation algorithms, and limited practical study of intensity modulation with electrons. With the availability of high energy electrons (up to 50 MeV) shaped using a computer-controlled multileaf collimator (MLC) system (Scanditronix MM50 Racetrack Microtron), the accuracy of electron dose calculations has become the primary obstacle to routine clinical use. In previously reported work, we have described the inability of a normal 3-D pencil beam model (McShan et al. Med. Phys. 1985) to accurately model the penumbra, divergence, and other aspects of MLC-shaped conformal electron fields over the wide range of SSDs and field sizes required for conformal therapy. In this work, a number of improvements to the 3-D pencil beam model are reported, including use of measured virtual source positions and collimator geometry details to accurately predict the field divergence and the penumbra region for different MLC and applicator geometries, and variation of pencil beam intensity across the field to better predict flatness for MLC and applicator fields as well as to permit dose calculations for intensity modulated fields. In addition, the descriptions of x-ray background and electron range straggling have been improved. Significant improvements in calculation accuracy are shown for scattered and scanned electron beams for a wide range of energies (up to 50 MeV), SSDs, collimation (MLC and applicator), and field shapes and sizes.