This paper introduces a methodology for simulation of binary random fields according to their prescribed autocorrelation function. It starts with a brief outline of the essential features of binary random fields and their implications in modeling two-phase random media. The exposition of the proposed methodology is done in two steps. In the first step, an algorithm is introduced to obtain samples of a binary field from generated realizations of a Gaussian field, using the theory of zero crossings of Gaussian fields. This mapping constitutes essentially a nonlinear transformation with memory of the Gaussian sample functions. In the second step, an iterative algorithm is introduced that allows the determination of the probabilistic characteristics of the underlying Gaussian field, so that the resulting binary field obtained through the proposed nonlinear transformation has a prescribed autocorrelation function. Several numerical examples are provided to demonstrate the capabilities of the methodology, especially in modeling two-phase random media. The methodology is shown to have a wide range of applicability and its computational cost is small, especially when a large number of realizations is needed.