Calculation of the ozone production potential of Volatile Organic Compounds (VOC) has traditionally been performed using so-called incremental reactivity techniques, requiring multiple photochemical model runs in which the effect on ozone from slight perturbations to each VOC is investigated in turn. A new approach to this problem is presented here using a single model run with an extensively tagged chemical mechanism. The results of this approach are consistent with previous work, but deliver much more detailed information about the VOC intermediate oxidation products involved in the production of ozone. We show that different classes of VOC exhibit very different temporal evolution in their ozone production potential, with alkenes and reactive aromatic VOC producing ozone rapidly, while the ozone production potential of alkanes increases in the day after they are emitted. We suggest that this is related to the speed with which these different classes of compounds are able to produce very small oxidation fragments. This multi-day ozone production potential has implications for emission control strategies for the management of air quality in polluted regions. We also relate the ozone production potential of VOC to the OH reactivity of the VOC oxidation intermediates, and show that the early oxidation products of alkenes and reactive aromatics are more efficient at producing ozone in their subsequent reactions with OH than similarly reactive alkanes. While this study examines idealised chemical conditions in a box model, the techniques employed here could potentially be adapted to the study of a wider range of real-world conditions using three-dimensional air quality models.