Overland Flow as Potential Land Disposal at the Umatac-Merizo Wastewater Treatment Plant, Southern Guam

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Introduction

The Guam Waterworks Authority is in the process of upgrading the majority of their wastewater treatment plants. The Umatac-Merizo Wastewater Treatment Plant (WWTP) treats and disposes of wastewater collected from the villages of Umatac and Merizo in the southern region of Guam, shown in Figure 1. Before designing drastic changes to the Umatac-Merizo WWTP treatment and disposal system, it would be beneficial to perform a GIS analysis of the existing overland flow system. Without investing incredible amounts in data collection, GIS tools can improve the planning process by providing quick links between the existing treatment and disposal system, the local topography, and surrounding climate.

Problem Statement

The Umatac-Merizo Wastewater Treatment Plant on the Island of Guam uses overland flow as part of its treatment processes. Can overland flow also be used as a potential wastewater land disposal system? Specifically, how much water can percolate through the overland flow terraces? How does the percolated amount compare to the typical precipitation on Guam?

Methodology

The GIS data obtained included street layers from the Government of Guam, soil types from the Water and Environmental Research Institute of the Western Pacific, and aerial base imagery from ESRI. All data specific to the Umatac-Merizo WWTP, including infiltrometer test results, were obtained from the Guam Waterworks Authority (GWA). The infiltrometer test results were mapped using the latitude and longitude information from the test logs, and reprojected to align with the UTM Zone 45M coordinate system used for all other data in the region. The overland flow terraces shown in Figure 2b were drawn based on the ESRI aerial base map and available design plans for the plant. Spatial analyses were performed to summarize data and limit the area of interest to the villages of Umatac and Merizo in the southern region of Guam.

The soil type prevalent in the area, was obtained from the GIS soils layer, but more accurate percolation rates were derived from the measured infiltration rates available using field calculations and statistics within ArcGIS. A porosity coefficient of 0.10 was used in the field calculations (Crites & Tchobanoglous, 1996). A simple comparison with the available precipitation data helped determine if the soil had enough capacity to act as land disposal process even after absorbing the typical precipitation amounts.

Results

The overland flow terraces of the Umatac-Merizo WWTP are located mostly on Akita-Badland soil complex, in an area with slopes between 7 and 15% as shown in Figure 3b. The derived percolation rate is 0.255 centimeters per hour (0.24 inches per day) which theoretically given the soil enough disposal capacity to reduce the treatment plant’s discharge effluent. The approximate disposal capacity for the 8.8 acres of overland terraces is 0.56 million gallons per day input throughout the year. Given an annual precipitation rate of 101 inches, the overland flow area could theoretically dispose of 0.51 mgd. If correctly graded, designed, and operated, the plant could have minimal discharge given the reported average flow of less than 0.39 mgd.

Conclusions

GIS analyses are only as accurate and as useful as the resolution of the data used. The difficulty of the project increased as the focus narrowed to the wastewater treatment plant’s parcel of land. The GWA infiltrometer tests proved to be significantly more useful than the general soils digitized map available from the Water and Environmental Research Institute. ArcGIS instantly performed statistics on the infiltration rate measurements, providing the average infiltration rate for the overland flow terraces. A field calculation was then used to obtain the percolation rate. The analysis had a positive outcome as the local soils can theoretically absorb through percolation a significant amount of water. However, viewing the infiltrometer tests locations on a map showed visually that the average infiltration rate used to calculate soil percolation may not be suit for the analysis. Based on the geographical distribution of the infiltration measurements (see Figure 4) a geometric mean of the measurements would more accurately represent the data.

Future work may involve using the geographic mean of the measured infiltration rates to evaluate a more accurate percolation rate for the existing soils. The total acreage required for both treatment and disposal may also increase due to other design considerations. For example, the overland flow terraces may need to be operated intermittently, providing rest time between wastewater distribution. Periods of intensive rainfall can result in overland flow that may need to be managed. The precipitation rate of the soil stays relatively constant throughout the year, but the precipitation and wastewater flows vary from season to season. A simple look at annual precipitation reveals an incomplete picture since storm events are significantly higher than the average daily rain. Figure 6 shows the monthly precipitation variability in the region.

Conclusions (continued)

Modeling or further evaluations will need to be performed to determine how much discharge the plant will generate during the wet season when the precipitation and wastewater flows both increase and can quickly exceed the soil’s disposal capacity. Specific storm events will need to be analyzed to better understand the limits of the disposal system. Storage may be a good solution in periods of intense rains, or the in-depth examination may reveal that discharge is inevitable.

References

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