### Two Nitrogens:

### Guidance for Determining Total Nitrogen

### and Ammonia Nitrogen Limits

Due to increasing environmental concerns with the accumulative effect of nutrient loading on water bodies, NPDES permit limits for Total Nitrogen are being given to more and more North Carolina POTWs which discharge to waters of the State. Often these Wastewater Treatment Plants (WWTPs) already have an NPDES limit for Ammonia Nitrogen. How do WWTP ORCs and Pretreatment Coordinators address these two different limits for two different forms of Nitrogen?

It is a Division requirement that POTWs include all NPDES limited parameters in their Long or Short Term Monitoring Plans (LTMP/STMP), and to develop Maximum Allowable Headworks Loading (MAHL) for these parameters in their Headworks Analysis.

Since by definition Ammonia Nitrogen is only a portion of the total nitrogen, one might expect the ammonia nitrogen MAHL to be at most equal to the total nitrogen MAHL, and typically lower. However, the MAHL method using the Pass-through Formula and historical data can often result in the reverse, a higher MAHL for ammonia nitrogen than for total nitrogen. This document discusses the makeup of nitrogen in wastewater, the current methodologies for calculating MAHLs for ammonia nitrogen and total nitrogen based on historical data, and a conservative SIU limit strategy for nitrogen.

### Nitrogen in Wastewater

Total nitrogen is comprised of organic nitrogen, ammonia nitrogen, nitrite and nitrate. The relationships are shown below.







The concentrations of each of the types of nitrogen in the WWTP influent depend on the composition of the discharges to the collection system and the conditions within the collection system prior to entering the WWTP. The main factors that control the balance of the nitrogen levels are the nature of the wastewater (proportion of domestic wastewater to industrial wastewater as well as characteristics of industrial wastewater), the availability of oxygen, the presence of certain types of bacteria, and temperature. Values for typical strength domestic wastewater as determined by Metcalf and Eddy, Inc, Wastewater Engineering Treatment, Disposal, and Reuse, Third Addition, 1991 are shown below.

# Typical Composition of Domestic Wastewater

|  |  |  |
| --- | --- | --- |
| Parameter | Average Concentration (mg/l) | Typical Range (mg/l) |
| Ammonia nitrogen | 25 | 12-50 |
| Nitrate + Nitrite | 0 | 0 |
| Organic Nitrogen | 15 | 8-35 |
| Total Nitrogen | 40 | 20-85 |

### The Nitrogen MAHLs

The standard approach to determining the MAHL for the different forms of nitrogen is to calculate a removal rate for each form using historical WWTP data and apply it to the NPDES limit for that form to derive an MAHL using the “pass-through” formula. Unfortunately, using this method can sometimes cause interesting things to happen. The following table shows the average influent and effluent concentrations, the determined removal rates, the NPDES Limits, and the MAHL for the different types of nitrogen, at an example activated sludge WWTP. An average flow rate was used to convert mg/l to a more typical lbs/day MAHL.

# Determination of MAHL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Average Influent Concentration (mg/l) | Average Effluent Concentration (mg/l) | Calculated Removal Rate | NPDES Limit (mg/l) | Calculated MAHL\* (lbs/day) |
| Ammonia nitrogen | 13.5 | 0.17 | 98.7% | 2 | 4,320 |
| Nitrate + Nitrite | 1.8 | 1.91 | -6% | - |  |
| Organic Nitrogen | 12.7 | 1.27 | 90% | - |  |
| Total Nitrogen | 28 | 3.35 | 88.0% | 6 | 1,368 |

\* Average WWTP Flow = 3.3 MGD

The table shows that in this example the MAHL for ammonia nitrogen is significantly greater than the MAHL for total nitrogen. The differences are caused by two main contributing factors:

1. This WWTP does not remove the different components of nitrogen at the same efficiency. Since it is very efficient at removing the ammonia nitrogen component but not nearly as effective at removing total nitrogen as a whole, the WWTP can treat a proportionally higher level of ammonia nitrogen as compared to the other types of nitrogen and still meet both NPDES limits.
2. The underlying basis for NPDES limits for Total Nitrogen and Ammonia Nitrogen are not directly related. Ammonia Nitrogen is potentially toxic to the aquatic life and can also deplete the dissolved oxygen levels within the receiving water as the ammonia nitrogen is converted to nitrate-nitrite in the stream. NPDES limits for Ammonia Nitrogen are developed to prevent these problems.

Total Nitrogen is limited in NPDES permits as a nutrient, usually in lake or estuary settings, where nitrogen accumulates and is the limiting nutrient for aquatic plant life, especially algae. A NPDES limit is typically based on a model that determines the maximum load that can be allowed without impairing the receiving water (i.e., causing a loss of designated use). The limit is set to help reduce the nitrogen loading to the receiving water so that over time the nutrient balance can be restored and/or maintained.

For many North Carolina WWTPs, including the example shown above, the Ammonia Nitrogen NPDES limit is lower than the Total Nitrogen limit, but the removal rate is higher. Both values are used in the Pass-through MAHL formula. In many cases, the higher removal rate for Ammonia Nitrogen has a greater influence on the resulting MAHL then the higher NPDES limit for Total Nitrogen, resulting in an ammonia nitrogen MAHL greater then the total nitrogen MAHL.

### SIU Limits for Nitrogen

When a POTW has an MAHL for total nitrogen that is lower than the ammonia nitrogen MAHL, the most straightforward method of addressing nitrogen is to limit all SIUs that need a limit (and/or SUO local limits) for either total nitrogen or ammonia nitrogen by assigning a total nitrogen limit using the total nitrogen MAHL as the basis. Since ammonia nitrogen is a part of total nitrogen, in most cases using this method the WWTP will automatically be protected against any NPDES compliance problems with ammonia nitrogen.

**NC POTWs must be aware that this method is a conservative and fairly simplistic way of addressing nitrogen and may not work for all POTWs. Two general examples are shown below**:

* For under loaded WWTPs, the total nitrogen MAHL developed using the Pass-through Formula may be unnecessarily limiting and not reflect the true capacity of the WWTP to treat total nitrogen. In this case, using the Design Formula to calculate the MAHL may produce a more appropriate Total Nitrogen MAHL.
* An SIU may have a very high proportion of ammonia nitrogen as compared to other forms of nitrogen. In this case, limiting this SIU for total nitrogen may unnecessarily limit this SIU since the WWTP capacity for ammonia nitrogen may be sufficient.

In either case, or **for a situation unique to a particular WWTP, the POTW may request Division approval of a different approach to limit ammonia nitrogen and total nitrogen. Contact the Division for additional guidance on the development of these MAHLs.**