

# Chapter 5

## Headworks Analysis Guidance

### Section A. Quick Reference Info

---

1. **Definition** - The headworks analysis is the determination of maximum allowable Publicly Owned Treatment Works (POTW) pollutant loadings under the typical POTW operating conditions based on the prevention of pass-through, prevention of wastewater treatment plant (WWTP) interference, assurance of sludge disposability, and the protection of POTW workers.
2. **Chapter Acronyms**
  - AT - Allocation Table
  - C - "Basic Freshwater", North Carolina Stream Classification
  - GWR - Groundwater Remediation
  - HASL - Headworks Addendum for Sludge Loadings
  - HQW - "High Quality Water", North Carolina Stream Classification
  - HWA - Headworks Analysis
  - LTMP - Long Term Monitoring Plan
  - MAHL - Maximum Allowable Headworks Loading
  - MAIL - Maximum Allowable Industrial Loading
  - NCGWQS - North Carolina Groundwater Quality Standard
  - NCWQS - North Carolina Water Quality Standard
  - OCPSF - Organic Chemicals, Plastics, and Synthetic Fibers
  - PEL - Permissible Exposure Level
  - POC - Pollutant of Concern
  - POTW - Publicly Owned Treatment Works
  - SAR - Sodium Adsorption Ratio
  - SIU - Significant Industrial User
  - STEL - Short Term Exposure Level
  - WWTP - Wastewater Treatment Plant
  - WS - "Water Supply", North Carolina Stream Classification
3. **Purpose** - To determine the MAHL, the uncontrollable loading, and the MAIL. The MAIL is the maximum loading the POTW can receive from its SIU's without failing a NPDES permit limit, an NCWQS or NCGWQS, interfering with the POTW, restricting the beneficial use of sludge, or impacting Worker Safety and Health.
4. **Regulatory References**
  - 40 CFR 403.5(c)-specific limits
  - NCGS 143-215-67(a) [Overallocation]
  - NPDES Part III
  - 15A NCAC .0905, .0906, .0907
5. **DEM Requirements**
  - HWA submitted per NPDES requirement, and
  - HWA submitted with LTMP data
6. **Implementation Frequency**
  - Minimum of once per five years, or
  - If significant POTW changes occur.

## Chapter 5 Headworks Analysis Guidance

### Section A. Quick Reference Info

---

#### 7. Appendices

- Appendix 5-A, Excel HWA Spreadsheet (Hardcopy)
- Appendix 5-B, Excel Organics HWA Spreadsheet (Hardcopy)
- Appendix 5-C, Headworks Analysis Hand Calculation Worksheets
- Appendix 5-D, Literature Removal Rates & Inhibition Thresholds
- Appendix 5-E, NCWQS from 15A NCAC 2B .0200
- Appendix 5-F, Removal Rate Worksheets
- Appendix 5-G, HWA and Organic HWA Spreadsheet Order Form
- Appendix 5-H, 40 CFR 503 Land Application of Residuals Limits
- Appendix 5-I, Non-Discharge Removal Rate Worksheet
- Appendix 5-J, NCGWQS from 15A NCAC 2L .0200
- Appendix 5-K, Headworks Addendum for Sludge Loadings (HASL) Worksheet

#### 8. Other Guidance Documents

- *EPA Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program, December 1987.*
- *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program, May 1991.*
- *PRELIM Version 4.0 User's Guide - Documentation for the EPA Computer Program for Development of Local Discharge Limitations Under the Pretreatment Program, May 1991.*

## Chapter 5 Headworks Analysis Guidance

### Section B. Discussion

---

An HWA can be considered a "snapshot" of the current POTW operating characteristics and the pollutant loading the POTW can handle without violating water quality standards (Pass-through and Interference), violating sludge standards, or endangering POTW workers. The HWA is a cornerstone of the pretreatment program as it provides the technical basis for SIU determination, and SIU permit limits. To provide data to complete a valid HWA the POTW designs and implements a LTMP.

### Section C. Methods of Completing an HWA

---

An HWA requires the completion of several calculations for each pollutant. These calculations can be completed by "hand", in a computer-based spreadsheet, or in EPA's HWA program (PRELIM 4.0). The choice of the method of completing the headworks analysis is the POTW's; however, the POTW must provide documentation of the calculations completed, the values chosen for the calculations, and the data from which the value was chosen.

Due to occasional "unsolvable problems" with the PRELIM 4.0 program and the difficulty of entering data, the Division is recommending the use of a computer-based spreadsheet for the HWA. The Division has developed HWA spreadsheets for Microsoft Excel for MacIntosh, Microsoft Excel for Windows, and Lotus 1-2-3 Version 2.01. A hardcopy of the Microsoft Excel spreadsheet is in Appendix 5-A. An order form for the specific spreadsheet formats is in Appendix 5-G. Upon request, the Division will provide the HWA spreadsheet formulas or a printout with HWA spreadsheet formulas.

Also, the Division has developed HWA "hand-calculation" worksheets. These worksheets are contained in Appendix 5-C and are self-explanatory.

For POTWs that have developed "working" PRELIM 4.0 based HWAs, please feel free to continue to use and update the HWA in PRELIM, or to switch to one of the other calculation methods.

### Section D. HWA Update Frequency and DEM Submittal Requirement

---

HWA must be submitted to the Division for approval per the POTW's NPDES or Non-Discharge requirement which is once per five years. However, with the rapid residential and industrial growth occurring in many regions of North Carolina, the HWA may not remain representative of the POTW for the five year period. The Division recommends that the HWA be updated if significant changes occur at the WWTP. Significant changes include:

- New NPDES or sludge disposal limits are issued,
- New NCWQS are established,
- a 10% increase in POTW average flow,
- if LTMP data indicates a 10% increase in the site-specific inhibition value, or
- any noticeable change in POTW removal rate.

It must be noted that the HWA may be updated for the entire set of POC's or for individual POC's. The updated HWA should be forwarded to the Division for review if the MAIL changes.



## Chapter 5 Headworks Analysis Guidance

### Section E. HWA Decisions and Calculations

---

Headworks analysis requires the evaluation of POTW and SIU data, along with water quality standards, inhibition criteria, sludge quality standards, and worker health and safety standards. These evaluations include the following:

#### Step 1. Removal Rate Determination

$$RR = (C_I - C_E) / C_I$$

and for those cases where corresponding influent and effluent flows exist

$$RR = (C_I Q_I - C_E Q_E) / C_I Q_I$$

where

RR = removal rate, as a decimal  
C<sub>I</sub> = influent concentration, mg/l  
C<sub>E</sub> = effluent concentration, mg/l  
Q<sub>I</sub> = influent flow, MGD  
Q<sub>E</sub> = effluent flow, MGD

- It is recommended that hydraulically paired data have removal rates calculated for each pair of data, and that the average of these paired removal rates be chosen for the removal rate value. Removal rates which are not typical of the POTW operation can be removed from the analysis; however, rationale for excluded data is required with the HWA submission.
- Influent and effluent data which is not hydraulically paired should have removal rates calculated using average influent and average effluent concentrations.
- Data below detection level. For many pollutants data will be below the detection level. The Division recommends the following procedure for data below detection level:
  - If more than 50% of the pollutant data is below the detection level, then use the literature (default) removal rate. Default removal rates are provided in Appendix 5-D.
  - If less than 50% of the pollutant data is below the detection level, then use 1/2 (one-half) the detection level as the datapoint value.
- Appendix 5-F contains removal rate calculation worksheets.
- Appendix 5-D lists the currently accepted literature "default" removal rates.

## Chapter 5 Headworks Analysis Guidance

### Section E. HWA Decisions and Calculations

---

#### Step 2. Passthrough Calculation.

Passthrough is the discharge of a pollutant above the discharge standard. For this calculation, we generally have two standards, NPDES limits and water quality standards; however, NPDES limits are derived from water quality standards.

**IF POLLUTANT HAS NPDES LIMIT, THEN THE POLLUTANT'S WATER QUALITY STANDARD SHOULD NOT BE EVALUATED.**

- NPDES limit calculation

$$L_{NPDES} = (8.34)(C_{NPDES})(Q_{POTW}) / (1 - RR_{POTW})$$

where

$L_{NPDES}$  = Allowable Headworks Loading based on NPDES limit, lbs/day

$C_{NPDES}$  = NPDES Permit Limit, mg/l

$Q_{POTW}$  = Average POTW Influent Flow, MGD

$RR_{POTW}$  = Removal Rate across POTW, as a decimal

- Water Quality Standard calculation

$$L_{WQS} = (8.34)(C_{WQS})(Q_{POTW} + Q_{STR}) / (1 - RR_{POTW})$$

where

$L_{WQS}$  = Allowable Headworks Loading based on WQS, lbs/day

$C_{WQS}$  = Water Quality Standard, mg/l

(Expanding and new discharges to HQW should use: 1/2 the NCWQS)

$Q_{POTW}$  = Average POTW Influent Flow, MGD

$Q_{STR}$  = Receiving Stream 7Q10 Flow, MGD except as follows:  
Phenols in "WS" streams use 30Q2 Flow, MGD, and  
Human Health Carcinogens use Average Flow, MGD

$RR_{POTW}$  = Removal Rate across POTW, as a decimal

- The POTW average influent flow is generally calculated using the average flow for all seven days of the week. However, at heavily industrial POTWs the flow from the five workdays may be significantly greater than the weekend flow. As such, you may use the average of the workday flow data. It must be noted that the SIUs that create these significant flow cycles should be flow equalized because WWTP operation may be damaged during these flow cycles.
- This equation does not account for background stream concentrations. Background stream data has been highly variable and difficult to interpret. At this time, background stream concentrations will be assumed to be zero. Stream concentrations above zero will be addressed in the Division's basin-wide modeling activities and future NPDES permits.
- NCWQS are provided in Appendix 5-E.
- Receiving stream flow information may be obtained from your NCDEM pretreatment contact.

## Chapter 5 Headworks Analysis Guidance

### Section E. HWA Decisions and Calculations

---

#### Step 3. Inhibition Calculation

- Secondary treatment threshold inhibition calculation

$$L_{2^{\circ}\text{INH}} = (8.34)(C_{2^{\circ}\text{INH}})(Q_{\text{POTW}}) / (1 - \text{RR}_{1^{\circ}})$$

where

$L_{2^{\circ}\text{INH}}$  = Secondary Inhibition allowable headworks loading, lbs/day

$C_{2^{\circ}\text{INH}}$  = Secondary Inhibition criterion, mg/l

$Q_{\text{POTW}}$  = Average POTW Influent Flow, MGD

$\text{RR}_{1^{\circ}}$  = Removal Rate across primary treatment, as a decimal

- Criteria to be used. Activated Sludge and Nitrification Criteria are indicated in Appendix 5-D. Most WWTP's have both carbonaceous and nitrogenous removal occurring in the activated sludge basin. To protect carbonaceous and nitrogenous organisms, the more stringent of the two criteria should be used. For instance, Nickel has an activated sludge inhibition threshold of 1 mg/l and a nitrification inhibition threshold of 0.25 mg/l. The most stringent criterion of 0.25 mg/l should be used.
- Appendix 5-D lists the currently accepted literature "default" inhibition values.
- Site specific inhibition thresholds: Some of the literature inhibition thresholds, especially copper (0.05 mg/l) and zinc (0.08 mg/l), appear to be too low for North Carolina's typical wastewater treatment plants. As such, site-specific inhibition criteria should be developed. The Division has concurred with site-specific inhibition thresholds based on the maximum influent concentration, on the maximum bioprocess concentration (basin concentration), and on pilot plant inhibition studies.
- Plants with multiple biological processes should modify the inhibition equation above. The modification is to find the appropriate inhibition criterion for the particular bioprocess, and to use the removal rate of all prior processes.
- Anaerobic digester threshold inhibition calculation

$$L_{\text{SLINH}} = (8.34)(C_{\text{SLINH}})(Q_{\text{DIG}}) / \text{RR}_{\text{POTW}}$$

where

$L_{\text{SLINH}}$  = Sludge Inhibition allowable headworks loading, lbs/day

$C_{\text{SLINH}}$  = Sludge Inhibition criteria, mg/l

$Q_{\text{DIG}}$  = Average Flow to Digester, MGD

$\text{RR}_{\text{POTW}}$  = Removal Rate across POTW, as a decimal

- Site specific inhibition thresholds: Generally, use of literature (default) sludge digester inhibition criteria for the HWA does not result in headworks analysis limiting criteria. However, if anaerobic digester inhibition is limiting the Division would consider site-specific inhibition thresholds based on the maximum sludge to digester concentration, on the maximum anaerobic digester concentration, and even on pilot anaerobic digester inhibition studies.
- Appendix 5-D lists the currently accepted literature "default" inhibition values.

# Chapter 5 Headworks Analysis Guidance

## Section E. HWA Decisions and Calculations

---

### Step 4. Sludge Disposal Calculation

Most POTWs with pretreatment programs are disposing of biosolids/"sludge" by land application and are subject to the 40 CFR 503 standards. The following equations determine sludge allowable loadings for the 40 CFR 503 regulations. For those facilities that do not land apply sludge, please review your disposal permits and contact DEM staff for assistance.

The 40 CFR 503 regulations are "self-implementing" with a compliance date of July 19, 1993. These regulations have four criteria for determining sludge disposability. These criteria are indicated in Appendix 5-H. The following equations represent the three criteria for "standard" sludge. If you wish to determine the allowable loadings for "high quality sludge", contact DEM staff for assistance.

- Annual Application Loading Determination

$$L_{SLANN} = (AAR)(SA) / ((RR_{POTW}) * (365 \text{ days/year}))$$

where

$L_{SLANN}$  = Annual application allowable headworks loading, lbs/day

AAR = Annual application rate criterion, lbs/(acre\*year)

SA = Site Area, acres

$RR_{POTW}$  = Removal Rate across WWTP, as a decimal.

- Cumulative Application Loading Determination

$$L_{SLCUM} = (CAR)(SA) / ((SL)(RR_{POTW}) * (365 \text{ days/year}))$$

where

$L_{SLCUM}$  = Cumulative application allowable headworks loading, lbs/day

CAR = Cumulative application rate criteria, lbs/acre

SA = Site Area, acres

SL = Site Life, years

$RR_{POTW}$  = Removal Rate across WWTP, as a decimal.

- Ceiling Concentration Loading Determination

$$L_{SLCEIL} = (8.34)(C_{CEIL})(PS / 100)(Q_{DISP}) / (RR_{POTW})$$

where

$L_{SLCEIL}$  = Ceiling Concentration allowable headworks, lbs/day

$C_{CEIL}$  = Sludge Ceiling Concentration, mg/kg

PS = Percent Solids

$Q_{DISP}$  = Sludge Flow to Disposal, MGD

$RR_{POTW}$  = Removal efficiency across WWTP, as a decimal.

- Land Application Residuals/Sludge Limits are listed in Appendix 5-H.



## Chapter 5 Headworks Analysis Guidance

### Section E. HWA Decisions and Calculations

#### Step 5. Maximum Allowable Headworks Loading (MAHL) Determination

The MAHL is the most stringent load (the lowest loading) calculated from the various criteria. The MAHL is the maximum predicted load that the POTW can handle from both SIU's and uncontrollable sources.

#### Step 6. Uncontrollable Load Determination

There are two methods of determining uncontrollable load. The methods can be described as the Uncontrollable Load Mass Balance Method and the Uncontrollable Sampling Method. The POTW may choose the method it uses; however, the Division recommends the Load Mass Balance Method. The Load Mass Balance Method is recommended due to the inherent difficulties in ensuring that the uncontrollable concentration value determined from site-specific sampling is valid.

- Uncontrollable Load Mass Balance Method

$$L_{UNCMB} = (8.34)(Q_{POTW})(C_{INF}) - (\sum (8.34)(Q_{SIU_n})(C_{SIU_n}))$$

where

$L_{UNCMB}$  = Uncontrollable Loading- Mass Balance, lbs/day

$Q_{POTW}$  = Average POTW Flow, MGD

$C_{INF}$  = Influent Pollutant Concentration, mg/l

$Q_{SIU_n}$  = SIU# average flow, MGD

$C_{SIU_n}$  = SIU# average discharge concentration, mg/l

- The  $\sum (8.34)(Q_{SIU_n})(C_{SIU_n})$  part of the formula is the calculation of the total average SIU load. Each SIU's average flow (in MGD) is multiplied by the SIU's average discharge concentration (in mg/l) and 8.34 to determine the load for each SIU. The sum of these individual SIU loads is the total average SIU load.
- For concentrations below the detection limit, the Division recommends the use of 1/2 half the detection limit. When submitting the HWA to the Division, the rationale for values chosen from below detection limit data must be discussed.
- If either the influent concentrations or SIU concentrations are typically below detection levels, then the uncontrollable sampling method should be used.

- Uncontrollable Sampling Method

$$L_{UNCS} = (8.34)(C_{UNC})(Q_{POTW} - \sum Q_{SIU_n})$$

where

$L_{UNCS}$  = Uncontrollable Loading - Sampling, lbs/day

$C_{UNC}$  = Uncontrollable Pollutant Concentration, mg/l

$Q_{POTW}$  = Average POTW Flow, MGD

$Q_{SIU_n}$  = SIU# average flow, MGD

- As previously stated it is difficult to gather representative uncontrollable sampling data. To increase the probability of gathering representative data, multiple sampling points should be used and as much data gathered as possible.

## Chapter 5 Headworks Analysis Guidance

### Section E. HWA Decisions and Calculations

#### Step 7. Maximum Allowable Industrial Loading (MAIL) Determination

The MAIL is the loading available for SIU's. The Division's criteria for determining overallocation of permit limits is based on the comparison of the MAIL and the most stringent (lowest) SIU permit flow and pollutant concentration.

$$\text{MAIL} = \text{MAHL} - \text{LUNC}$$

where

MAIL = Maximum Allowable Industrial Loading, lbs/day

MAHL = Maximum Allowable Headworks Loading, lbs/day

LUNC = Uncontrollable Loading, lbs/day

To ensure that overallocation has not occurred:

$$\text{MAIL} \geq \sum((8.34)(Q_{\text{SIUn}})(C_{\text{SIUn}}))$$

where

MAIL = Maximum Allowable Industrial Loading, lbs/day

$Q_{\text{SIUn}}$  = SIU# most stringent (lowest) permitted flow, MGD

$C_{\text{SIUn}}$  = SIU# most stringent (lowest) permitted discharge concentration, mg/l

- Allocation is checked by completing an allocation table as described in the IUP Chapter 6.

## Chapter 5 Headworks Analysis Guidance

### Section F. Organic Chemical Headworks Analysis

---

Organic chemical HWA's are more difficult to complete than HWA's for conventional pollutants and metals primarily because of difficulties in determining applicable water quality standards and due to Safety and Health Issues.

- **Applicable Water Quality Standards**

For the majority of organic pollutants North Carolina has not adopted a water quality standard. For pollutants that do not have water quality standards, all appropriate water quality criteria must be examined. Generally for organic pollutants, water quality screening values or federal criteria exist for chronic effect protection of human health and aquatic life. Appendix 5-B is the Division's organic headworks analysis spreadsheet which includes a listing of the currently approved criteria for "several" of the organics.

- It must be noted that the stream flow for chronic effects of aquatic life is the 7Q10 stream flow, and that the stream flow for human health effects is the 7Q10 stream flow for non-carcinogens and is the average streamflow for carcinogens.
- It must also be noted that there are two sets of human health criteria. The "Class C" set is based on human health protection from consumption of fish, and the "Class WS" set is based on human health protection from consumption of the water and the fish.

- **Safety and Health Issues**

There are two primary safety and health issues. These issues are explosivity and the harmful effects of exposure to toxic gases. These issues are discussed in detail in the EPA "Guidance to Protect POTW Workers from Toxic and Reactive Gases and Vapors." These criteria are generally applied as permit limit instantaneous maximums to be applied at the end of the SIU's discharge pipe.

- It must be noted that the Short Term Exposure Limit (STEL) limits are generally based on 15 minute exposures to the pollutant and that the Permissible Exposure Limit (PEL) limits are based on 8 hour time weighted average exposure to the pollutant. The Division allows the establishment of pollutants limits to protect against either STEL or PEL pollutant concentrations.
  - Appendix 5-B is the Division's organic headworks analysis spreadsheet which includes a listing of the currently approved explosivity, STEL and PEL values for "several" of the organics.
- **Removal Rate Determination**

Organic removal rates will generally be taken from literature sources. The primary literature source is the "RREL Treatability Data Base." Conservatively, when the Division establishes a removal rate for a pollutant from RREL data, the average of the removal rates from the lowest concentration data available is used.

## Chapter 5 Headworks Analysis Guidance

### Section F. Organic Chemical Headworks Analysis

---

- Appendix 5-B is the Division's organic headworks analysis spreadsheet which includes a listing of the currently approved default removal rates for "several" of the organics. It is recommended that facilities which have detectable quantities of effluent organics develop site-specific organic removal rates for the organics detected.
- The RREL treatability database may be obtained from:

Mr. Glenn M. Shaul  
USEPA  
Mailstop 445  
26 West Martin Luther King Drive  
Cincinnati, Ohio 45268

or fax a request to (513)569-7787.

- **Completing the Division Standard Organics HWA Spreadsheet**

At this time, the Division will complete the Division Standard Organics HWA spreadsheet for the POTW at their request. The Municipality will have to provide minimal information to the Division. Contact your NCDEM pretreatment contact to obtain a completed Standard Organics HWA spreadsheet for your facility.

The spreadsheet is designed to calculate permit limits that would not automatically qualify the discharger as an SIU, i.e. less than 5% of the MAHL; however, the spreadsheet can be modified to ignore the SIU determination calculation.

Municipalities that wish to complete a site-specific or modified organics HWA may request a diskcopy of the Standard Organics HWA spreadsheet. Appendix 5-G provides the spreadsheet request form.

## Chapter 5 Headworks Analysis Guidance

### Section G. Typical Prelim 4.0 Problems

---

- The Inhibition Warning:

**Based on input values, the current actual loadings to the unit process exceeds the calculated inhibition value for the pollutant: XXXXXXXX**

**Has any inhibition of the unit process occurred due to the current loadings (Y/N)?**

If in computing the headworks analysis, PRELIM prompts you with the message above it actually means that influent to the process is greater than the inhibition value you entered. If you check "yes," then the program will calculate inhibition based on the inhibition value chosen. If you check "no," then the program will calculate inhibition based on the average influent concentration entered. Neither choice is correct. Instead, it is recommended that you enter a site-specific inhibition value for the pollutant. For pollutants which do not have inhibition values, you should enter an extremely large value(10,000) for the inhibition value to prevent this message.

- Entering IU data

PRELIM allows you to enter an industrial user average for each pollutant at each industry. PRELIM uses this data on Report 5 to determine if you are currently overloaded and in subsequent reports to develop limits (Report 6, 7, & 8). It must be noted that the industrial user data entered in PRELIM are not used in the calculation of the MAHL, the uncontrollable load, or the MAIL. In other words, entering the industrial data does not affect the HWA, and can be omitted. Most POTWs do not use the limit determination methods of the PRELIM method and will not use Report 6, Report 7, or Report 8. The method we use to determine overallocation is the allocation table. It must be noted that the industrial user data entered in PRELIM are not used in the calculation of the MAHL, the uncontrollable load, and the MAIL.

The Division recommends that the municipality determine the total average industrial load as part of calculating the uncontrollable load, rather than entering data for each individual SIU. It is relatively simple to determine the total average industrial load from a hand or computer calculated spreadsheet. From this total average industrial load and the "total" average industrial flow, a "total" average industrial concentration can be calculated. The "total" average industrial flow and the "total" average industrial concentration may then be entered in the industrial user data section of PRELIM as opposed to the individual user data.

- Entering Removal Rates Recommendation

PRELIM offers two choices for entering removal rates. One choice is to enter a single user chosen value in Data Sheet 2. The other choice is to use either Data Sheet 3 or 3A which will allow the user to choose the mean, the average, the median or a particular decile removal rate. However, when using Data Sheet 3 or 3A the PRELIM output does not indicate the choices for the removal rate, which makes it almost impossible to determine which removal rate value was chosen. The Division recommends that the removal rate choice be completed either from a hand calculated or computer calculated spreadsheet. Appendix 5-F contains removal rate calculation worksheets. The removal rate choice should then be entered in Data Sheet 2.



## Chapter 5 Headworks Analysis Guidance

### Section H. Treatable Pollutant HWA Discussion

---

For this discussion, "treatable pollutants" are pollutants which a wastewater treatment plant is designed to remove. For most wastewater treatment plants the only "treatable pollutants" are BOD and TSS; however, at advanced wastewater treatment plants, treatable pollutants may include ammonia-nitrogen, total nitrogen, phosphorus, color, and even metals.

At some WWTP's, the WWTP is operating all processes at maximum capability and the removal rate calculated from site-specific data is indicative of the achievable removal rate. In these cases, the standard HWA as discussed in Section E of this chapter is appropriate. Also, in these cases the pollutant may need to be limited in the IUPs, and the SIUs may have to install additional pretreatment devices because the WWTP does not have sufficient treatment capacity.

At other WWTP's, the WWTP is not operating all processes at their maximum capability. For instance, the WWTP may be cycling aerators on and off but maintaining appropriate Dissolved Oxygen for removal of the biodegradable pollutants because the WWTP is not fully loaded (even underloaded), or the WWTP may have the capability of adding additional treatment chemicals to remove the pollutants. In these cases, the standard HWA as discussed in Section E of this chapter may underestimate the treatment capacity of the WWTP, because the removal rate calculated from site-specific data is not indicative of the "achievable removal rate" at maximum capability. For these cases, it is appropriate to determine a design treatment capacity of the pollutant.

The design treatment capacity is determined from design calculations for the specific unit processes at the WWTP. For instance, the available oxygen (blower or aerator size) is generally the controlling factor for BOD treatment capacity, or the controlling factor may be the chemical addition rate (feed pump size) for chemical addition treatment (for instance the quantity of alum which can be added for phosphorus removal).

The design treatment capacity for your WWTP was determined by the WWTP consultants and engineers and may be provided in the operation and maintenance manuals; however, updated design calculations may have been generated for WWTP upgrades or expansions. To submit a HWA based on design treatment capacity, the POTW must submit the design calculations and process specifications for the removal process, and if available any jar tests or bench scale studies. The Division will review the design calculations and discharge data and may allow the design treatment capacity to be used as the MAHL for the WWTP. Plants with Whole Effluent Toxicity problems or poor performance records for treatable pollutant removal will be closely reviewed to ensure that additional loadings will not worsen the plant performance.

The design calculations may not be as accurate an estimate of MAHL as the MAHL determined from site-specific data for a treatment plant at maximum capability. Therefore, the Division strongly recommends that the POTW maintain a large percentage of "Total loading still available" as a safety factor for the estimation inaccuracies.

The goal of using the design treatment capacity for HWA is to prevent the purchase, operation and maintenance of redundant treatment devices at SIUs when the WWTP has the capability to treat the waste. As always, the POTW may recover the costs of treating the industrial waste through a surcharge program.

## **Chapter 5 Headworks Analysis Guidance**

### **Section H. Treatable Pollutant HWA Discussion**

---

WWTPs with multiple treatment trains should be especially careful when using the design treatment capacity for HWA. Consideration should be given to the capability to operate all treatment trains even during wet weather and maintenance shutdowns, and the costs of operating additional treatment trains for the additional loading from an SIU. The current number of treatment trains operating and the number of treatment trains available must be indicated in the submission of a design treatment capacity HWA for a multiple treatment train WWTP.



## Chapter 5 Headworks Analysis Guidance

### Section I. NC Action Levels Discussion

---

North Carolina has established Freshwater Action Levels for the pollutants: Chloride, Total Residual Chlorine, Copper, Iron, Silver, and Zinc. These action levels are applied differently than other water quality standards. The NC Administrative Code 15A .0211 (b)(4) states that:

"...Those substances for which Action Levels are listed...will be limited as appropriate in the NPDES permit based on the Action Levels listed... if sufficient information... exists to indicate that any of those substances may be a significant causative factor resulting in toxicity of the effluent."

In other words, the action level criteria will not be used as the basis for limits in an NPDES permit unless the chemical has been shown to be responsible for effluent toxicity.

**As such, the use of the action level criteria are not required for HWA at WWTPs without whole effluent toxicity, or at WWTPs with whole effluent toxicity that has not been indicated to be caused by Action Level pollutants.**



## Chapter 5 Headworks Analysis Guidance

### Section J. Non-discharge HWA Decisions and Calculations

**This Section outlines HWA methods for Lagoon WWTPs that have a Spray Irrigation effluent disposal system. For other types of Non-Discharge WWTPs, please contact DEM for assistance.**

**A headworks analysis requires the evaluation of POTW and SIU data, along with water quality standards, inhibition criteria, sludge quality standards, and worker health and safety standards. These evaluations include the following:**

#### Step 1. Lagoon Removal Rate Determination

- **As lagoon WWTPs have hydraulic retention times typically 30 to 90 days, the Division recommends in the LTMP guidance that the influent and effluent WWTP sampling be conducted at the same time, rather than staggered to take into account hydraulic retention times. Therefore, influent and effluent data should have removal rates calculated using average influent and average effluent concentrations.**
- **Average the influent data and the effluent data, and use the following formulas.**

$$RR = (C_I - C_E) / C_I$$

where

**RR = removal rate, as a decimal**

**C<sub>I</sub> = average influent concentration, mg/l**

**C<sub>E</sub> = average effluent concentration, mg/l**

- **Data below detection level. For many pollutants, data will be below the detection level. The Division recommends the following procedure for data below detection level:**
  - **If more than 50% of the pollutant data is below the detection level, then use the literature (default) removal rate. Default removal rates are provided in Appendix 5-D, page 2. For lagoons, the Division will accept use of primary literature removal rates.**
  - **If less than 50% of the pollutant data is below the detection level, then use 1/2 (one-half) the detection level as the data point value.**
- **Appendix 5-I contains removal rate calculation worksheets.**
- **Appendix 5-D, page 2, lists the currently accepted literature "default" removal rates.**

#### Step 2. Passthrough/Design Calculation.

**Passthrough is the discharge of a pollutant above the discharge standard. For Spray Irrigation WWTPs, this refers to pollutants affecting human health or other environmental concerns, either through introduction into the cover crop or through leaching of pollutants through the soil to the groundwater. Currently, the Division requires that the POTW evaluate the WWTP design parameters, such as BOD, TSS, NH<sub>3</sub> as N/TKN, etc. Additionally, the Division requires that the POTW evaluate Sodium Absorption Ratio. Finally, where the POTW's Non-Discharge permit requires groundwater monitoring for pretreatment Pollutant of Concerns (POCs), the Division requires that the**

## Chapter 5 Headworks Analysis Guidance

### Section J. Non-discharge HWA Decisions and Calculations

---

POTW submit a summary of the POTW's most recent two years of groundwater monitoring well data (example data summary form found in Appendix 4-B) with a comparison of the data to the NC Groundwater Standards. If this data shows the potential for Standards violations, additional evaluations may be required on a case-by-case basis.

In addition to these requirements, the Division recommends that the POTW evaluate Cumulative Application Loading Rates from 40 CFR 503 and NC Groundwater Quality Standards.

- **Design Parameters Evaluation** - The HWA must include an evaluation of the WWTP treatment capacity for the pollutants the WWTP is designed to remove. Typically, these parameters include BOD, TSS, and NH<sub>3</sub> as N/TKN. The evaluation should provide a brief discussion of the WWTP design criteria for these parameters, with applicable calculation of maximum allowable headworks load, and a comparison of current operation level as compared to design. At minimum, the TSS discussion must address irrigation equipment nozzle size. At minimum, the NH<sub>3</sub> as N/TKN discussion must address lagoon detention time and nitrification/denitrification.
- **Sodium Adsorption Ratio (SAR) Determination** - The HWA must include an evaluation of the SAR for the WWTP, and the need to regulate any SIUs for the SAR pollutants.
  - The HWA submission must include the WWTP influent, effluent, and SIU data for Na, Ca, and Mg, and the associated SARs. The SAR formula is

$$\text{SAR} = (\text{Na}) / (\text{Square root of } ((\text{Ca} + \text{Mg})/2))$$

where

SAR = Sodium Adsorption Ratio

Na = Sodium, meq/100 cm<sup>3</sup>

Ca = Calcium, meq/100 cm<sup>3</sup>

Mg = Magnesium, meq/100 cm<sup>3</sup>

- If the SAR is above 10, then identify whether the source is industrial or uncontrollable, and discuss steps the POTW is taking to address the SAR. If the source is industrial, discuss whether limits and/or monitoring will be needed in the IUP.
- **Groundwater Quality Standard calculation**

$$L_{\text{NCGWQS}} = (8.34)(C_{\text{NCGWQS}})(Q_{\text{POTW}}) / (1 - RR_{\text{POTW}})$$

where

$L_{\text{NCGWQS}}$  = Allowable Headworks Loading based on NC Groundwater Quality Standard, lbs/day

$C_{\text{NCGWQS}}$  = NC Groundwater Quality Standard, mg/l

$Q_{\text{POTW}}$  = Average POTW Influent Flow, MGD

$RR_{\text{POTW}}$  = Removal Rate across POTW, as a decimal

## Chapter 5 Headworks Analysis Guidance

### Section J. Non-discharge HWA Decisions and Calculations

---

- For those facilities that wish to get credit for the metals removal by the soil, please contact DEM staff for assistance.
  - The POTW average influent flow is generally calculated using the average flow for all seven days of the week. However, at heavily industrial POTWs the flow from the five workdays may be significantly greater than the weekend flow. As such, you may use the average of the workday flow data. It must be noted that the SIUs that create these significant flow cycles should be flow equalized because WWTP operation may be damaged during these flow cycles.
  - NCGWQS are provided in Appendix 5-J.
- Cumulative Application Loading Determination

$$L_{SLCUM} = (CAR)(SA) / ((SL)(1 - RR_{POTW}) * (365 \text{ days/year}))$$

where

$L_{SLCUM}$  = Cumulative application allowable headworks loading, lbs/day

CAR = Cumulative application rate criteria, lbs/acre (Appendix 5-H)

SA = Site Area, acres

SL = Site Life, years

$RR_{POTW}$  = Removal Rate across WWTP, as a decimal.

#### Step 3. Inhibition Calculation

The Division does not require evaluation for lagoon WWTPs as lagoons are considered a primary treatment unit. If the POTW wishes to evaluate inhibition, DEM will consider the proposal.

#### Step 4. Sludge Disposal Calculation

For lagoon systems that do not routinely remove the biosolids or "sludge" accumulating in the lagoon, the POTW should submit the sludge blanket analysis data (required as part of the Non-Discharge LTMP) with the HWA, with a comparison of the data to 40 CFR 503 sludge ceiling concentrations (see Appendix 5-H for values for typical POCs) and to 40 CFR 261 hazardous waste concentrations for POCs. The POTW should discuss any potential for problems with future sludge handling.

For those facilities that do remove the biosolids/"sludge" for disposal for some methods other than land application, compare your sludge data to any limits in your disposal permit, 40 CFR 503.

#### Step 5. Maximum Allowable Headworks Loading (MAHL) Determination

The MAHL is the most stringent load (the lowest loading) calculated from the various criteria. The MAHL is the maximum predicted load that the POTW can handle from both SIU's and uncontrollable sources.

## Chapter 5 Headworks Analysis Guidance

### Section J. Non-discharge HWA Decisions and Calculations

---

#### Step 6. Uncontrollable Load Determination

There are two methods of determining uncontrollable load. The methods can be described as the Uncontrollable Load Mass Balance Method and the Uncontrollable Sampling Method. The POTW may choose the method it uses; however, the Division recommends the Load Mass Balance Method. The Load Mass Balance Method is recommended due to the inherent difficulties in ensuring that the uncontrollable concentration value determined from site-specific sampling is valid.

- **Uncontrollable Load Mass Balance Method**

$$L_{UNCMB} = (8.34)(Q_{POTW})(C_{INF}) - (\sum (8.34)(Q_{SIUn})(C_{SIUn}))$$

where

$L_{UNCMB}$  = Uncontrollable Loading- Mass Balance, lbs/day

$Q_{POTW}$  = Average POTW Flow, MGD

$C_{INF}$  = Influent Pollutant Concentration, mg/l

$Q_{SIUn}$  = SIU# average flow, MGD

$C_{SIUn}$  = SIU# average discharge concentration, mg/l

- The  $\sum (8.34)(Q_{SIUn})(C_{SIUn})$  part of the formula is the calculation of the total average SIU load. Each SIU's average flow (in MGD) is multiplied by the SIU's average discharge concentration (in mg/l) and 8.34 to determine the load for each SIU. The sum of these individual SIU loads is the total average SIU load.
- For concentrations below the detection limit, the Division recommends the use of 1/2 half the detection limit. When submitting the HWA to the Division, the rationale for values chosen from below detection limit data must be discussed.
- If either the influent concentrations or SIU concentrations are typically below detection levels, then the uncontrollable sampling method should be used.

- **Uncontrollable Sampling Method**

$$L_{UNCS} = (8.34)(C_{UNC})(Q_{POTW} - \sum Q_{SIUn})$$

where

$L_{UNCS}$  = Uncontrollable Loading - Sampling, lbs/day

$C_{UNC}$  = Uncontrollable Pollutant Concentration, mg/l

$Q_{POTW}$  = Average POTW Flow, MGD

$Q_{SIUn}$  = SIU# average flow, MGD

- As previously stated it is difficult to gather representative uncontrollable sampling data. To increase the probability of gathering representative data, multiple sampling points should be used and as much data gathered as possible.

## Chapter 5 Headworks Analysis Guidance

### Section J. Non-discharge HWA Decisions and Calculations

---

#### Step 7. Maximum Allowable Industrial Loading (MAIL) Determination

The MAIL is the loading available for SIU's. The Division's criteria for determining overallocation of permit limits is based on the comparison of the MAIL and the most stringent (lowest) SIU permit flow and pollutant concentration.

$$\text{MAIL} = \text{MAHL} - \text{LUNC}$$

where

MAIL = Maximum Allowable Industrial Loading, lbs/day

MAHL = Maximum Allowable Headworks Loading, lbs/day

LUNC = Uncontrollable Loading, lbs/day

To ensure that overallocation has not occurred:

$$\text{MAIL} \geq \sum((8.34)(Q_{\text{SIUn}})(C_{\text{SIUn}}))$$

where

MAIL = Maximum Allowable Industrial Loading, lbs/day

$Q_{\text{SIUn}}$  = SIU# most stringent (lowest) permitted flow, MGD

$C_{\text{SIUn}}$  = SIU# most stringent (lowest) permitted discharge concentration, mg/l

- Allocation is checked by completing an allocation table as described in the IUP Chapter 6.





## Chapter 5 Headworks Analysis Guidance

### Section K. Headworks Addendum for Sludge Loadings (HASL)

---

If you do not have a problem with MAHL's based on the sludge criteria you do not need to read this section of the Comprehensive Guide or complete the Headworks Addendum for Sludge Loadings (HASL) worksheets. However, please be aware that the sludge information used in your Headworks Analysis (HWA) must match the information in your Annual Sludge Reports.

#### **Causes for Sludge based MAHL problems:**

The primary cause of very low sludge-based MAHL's are POTW's that generate and dispose of little or no sludge. For example, even if you have very low or BDL concentrations of Metal-X in your influent and effluent, the Headworks Analysis uses the removal rate to calculate how much Metal-X goes into your sludge. Now, if you only dispose of one quart of sludge a year, all of Metal-X is concentrated in that one quart of sludge. Then when you land apply that sludge on one square foot of farm land. Bingo! you have told the computer that you have taken the Metal-X in your influent, concentrated it so much that it may even be a hazardous waste sludge, and spread it all over the county.

Have you really done something wrong? Probably not, but this section will help if you have sludge-based MAHL's in your HWA that are not verified by actual sludge data.

WWTP's must accurately quantify the capture, recycle, digestion, storage, and disposal of their solids (even during extreme flows & even better than permitted TSS of 30 mg/l) in order for the mass balance equations in the Headworks Analysis to give true and reliable results. How many solids do you "lose" during extreme rain events and other "unusual situations"?

#### **POTW's with Sludge based MAHL problems:**

Some POTW's have had problems with extremely low headworks analysis Maximum Allowable Headworks Loadings (MAHLs) based on one of the three sludge criteria:

1. Annual Loading Rate
2. Cumulative Loading Rate
3. Ceiling Concentration Limits

If you do have a problem with MAHL's based on the sludge criteria this section was developed to help you identify sludge based MAHL's that place unreasonable limitations on your POTW and your SIUs.

What is an unreasonable MAHL? If your POTW is operating well, compliant with its NPDES permit and sludge permit, passing toxicity tests, and have issued IUPs with reasonable limits and your sludge based MAHL's cause over allocations, cause SIUs to be in SNC, require industries to install unnecessary pretreatment devices, or cause industries to relocate or shut down? Then these MAHL's may be unreasonable.

This section provides an alternative method to determine a MAHL for a pollutant if the sludge based MAHL calculated in your Headworks Analysis are not representative of the actual sludge data reported in your Annual Sludge Reports.

## Chapter 5 Headworks Analysis Guidance

### Section K. Headworks Addendum for Sludge Loadings (HASL)

---

#### **SOLUTION for POTW's with sludge based MAHL problems:**

The Headworks analysis Addendum for Sludge Loading (HASL) addresses the problems of extremely low sludge based MAHL's by looking carefully at the actual sludge data collected by the POTW. If the data in the Annual Sludge Reports shows that there is not a problem with either the land application of sludge or the concentration of metals in the sludge then the sludge based MAHL's calculated with the Headworks Analysis equations (used in both prelim, and the Division's Excel spreadsheet) are not used. See Appendix 5-K, for the Headworks Addendum for Sludge Loading worksheet.

#### **POTW's with good Sludge**

If the POTW's Annual Sludge Reports demonstrate conclusively that the POTW is and has been meeting all the sludge criteria with a 20 % safety factor, the Division will allow the POTW to use the next most restrictive criteria (NPDES, WQ Std, Inhibition) in the HWA for assigning their MAHL. The POTW's sludge would have to meet the following criteria:

1. Loading (lbs/acre) on their most heavily loaded field during the past year is less than 80% of the annual sludge loading rate limits.
2. Loading (lbs/acre) on their most heavily loaded field is less than 80% of the cumulative sludge loading rate limits.
3. The field with the heaviest cumulative loading has at least 5 years of capacity left, even if it received the heaviest annual loading for the next 5 years.
4. Average sludge concentration is less than 80 % of the Sludge Ceiling Concentration Limits.

#### **POTW's with marginal Sludge**

If the POTW's sludge concentration and/or land application data demonstrate that the POTW has values between 80% and 99.9% of any of the sludge criteria limits (i.e., has less than a 20% safety margin) the Division will allow the POTW to use the next most restrictive criteria (NPDES, WQ Std, Inhibition) for assigning their MAHL. However, the HWA and IUP's will only be approved for 1 year and the POTW must prepare and submit a Land Application and Metals Management Plan. A land management plan must show acquisition of more land and/or better management of the existing land used for sludge application. The metals management plan must show a reduced loading of metals from industry including waste minimization and pollution prevention.

## Chapter 5 Headworks Analysis Guidance

### Section K. Headworks Addendum for Sludge Loadings (HASL)

---

#### POTW's with Sludge Violations

If the POTW's sludge concentration and/or land application data demonstrate that the POTW has values that exceed any of the sludge criteria limits the Division will require the POTW to calculate a MAHL based on sludge violations according to the following equation. This MAHL will be compared to the original sludge based MAHL's calculated in the HWA, and the most restrictive MAHL used. The HWA and IUP's will only be approved for 1 year and the POTW must also prepare and submit a Land Application and Metals Management Plan.

#### EXAMPLE:

If a POTW had a cadmium sludge concentration value 117% of the limit:  
The POTW would need to reduce their cadmium MAHL.

Equation:

$$\begin{aligned} \text{MAHL}_{sv} &= \text{MAHL based on sludge violations} \\ &= (Q_{potw} * C_{inf\_cad} * 8.34) / (\%_{adj}) \\ &= (2.5 \text{ mgd} * .035 \text{ mg/l} * 8.34) / 1.17 \\ &= .6237 \text{ lbs/day of cadmium} \end{aligned}$$

Where:

<u>Variable Name</u>	<u>Value</u>	<u>Units</u>	<u>Description</u>
Q_potw =	2.5	mgd	Average POTW flow
C_inf_cad =	.035	mg/l	Average influent conc. of cadmium
%_adj =	1.17	as decimal	Percentage adjustment required by sludge violation for example, enter 117% as 1.17
Conv. factor =	8.34	none	Conversion factor 8.34

