TNRCC

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Fourteen Total Maximum Daily Loads for Nickel in the Houston Ship Channel System

For Segments 1001, 1005, 1006, 1007, 1013, 1014, 1016, 1017, 2426, 2427, 2428, 2429, 2430, and 2436

Prepared by the:
Strategic Assessment Division
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TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

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Introduction

Section 303(d) of the Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. For each listed water body that does not meet a standard, states must develop a total maximum daily load (TMDL) for each pollutant that has been identified as contributing to the impairment of water quality in that water body. The Texas Natural Resource Conservation Commission (TNRCC) is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

In simple terms, a TMDL is a quantitative plan that determines the amount of a particular pollutant that a water body can receive and still meet its applicable water quality standards. In other words, TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load, with units of mass per time period, but may be expressed in other ways also. TMDLs must also estimate how much the pollutant load needs to be reduced from current levels in order to achieve water quality standards.

The Total Maximum Daily Load Program, a major component of Texas' statewide watershed management approach, addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries (water bodies) in or bordering the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses (such as drinking water, recreation, support of aquatic life, or fishing) of impaired or threatened water bodies.

The ultimate goal of these TMDLs is to reduce nickel pollution in the Houston Ship Channel in order to protect the aquatic life use.

Enumeration and counting of TMDLs for tracking and reporting purposes considers each combination of one water body and one pollutant as one TMDL. This document discusses TMDL allocations for a single pollutant (dissolved nickel) for 14 designated segments (water bodies), but describes a single project. Combining multiple TMDLs into single projects allows a more holistic and integrated assessment of pollutant effects and necessary management measures. Singular tense references to "the TMDL" are used within this document for the sake of clear communication regarding this singular project. However, for purposes of satisfying Clean Water Act requirements, this single project and document constitutes 14 individual TMDLs, and will be counted that way for reporting purposes.

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 Code of Federal Regulations, Section 130) describe the statutory and regulatory requirements for acceptable TMDLs. The TNRCC guidance

document, *Developing Total Maximum Daily Load Projects in Texas* (GI-250), further refines the process for Texas. Following all these guidelines, this TMDL document has been prepared and is composed of six elements which are summarized in the following sections:

- Problem Definition
- Endpoint Identification
- Source Analysis
- Linkage Between Sources and Receiving Waters
- Margin of Safety
- Loading Allocations

This TMDL document was prepared by:

- the Standards and Assessment Section in the Water Permits and Resource Management Division of the Office of Permitting, and the
- TMDL Team in the Strategic Assessment Division of the Office of Environmental Policy, Analysis, and Assessment of the Texas Natural Resource Conservation Commission.

The 14 TMDLs described in this document were adopted by the Texas Natural Resource Conservation Commission on June 14, 2002. Upon adoption, the TMDLs became part of the state Water Quality Management Plan. The Texas Natural Resource Conservation Commission will use this document in reviewing and making determinations on applications for wastewater discharge permits and in its nonpoint source pollution abatement programs.

Problem Definition

These TMDLs were developed for dissolved nickel in the Houston Ship Channel System, a network of water bodies in the vicinity of Houston, Texas (see Figure 1). The designated water quality segments that comprise the Houston Ship Channel System (HSC) are the San Jacinto River Tidal (Segment 1001), Houston Ship Channel (Segments 1005, 1006, 1007), Buffalo Bayou (Segments 1013 and 1014), Greens Bayou Above Tidal (Segment 1016), Whiteoak Bayou Above Tidal (Segment 1017), Tabbs Bay (Segment 2426), San Jacinto Bay (Segment 2427), Black Duck Bay (Segment 2428), Scott Bay (Segment 2429), Burnett Bay (Segment 2430), and Barbours Cut (Segment 2436). The analyses and allocations of these TMDLs also cover the undesignated tidal and non-tidal tributary waters of those designated segments. These TMDLs will quantify the dissolved nickel load allocation using existing QUAL-TX models of the HSC and the wasteload allocation using the TEX-TOX model for the protection of the aquatic life chronic criterion under critical low flow conditions (margin of safety).

Data collected during the late 1980's and early 1990's caused some concern about dissolved nickel concentrations in the Houston Ship Channel System. That concern, in conjunction with the large number of discharges to the system and the absence of dependable data, instigated further investigation of water column concentrations of

nickel. The analyses and allocations documented in this TMDL report were completed to finally resolve concerns about nickel in the Houston Ship Channel System, and to incorporate the results into the State water quality management plan.

Numerous data collected using modern clean methods for sampling and analysis have alleviated the initial concern, and verified that the pre-1993 data are unsuitable for determining attainment of water quality standards for nickel. The modern data indicate that water quality standards for dissolved nickel are being met in the Houston Ship Channel System.

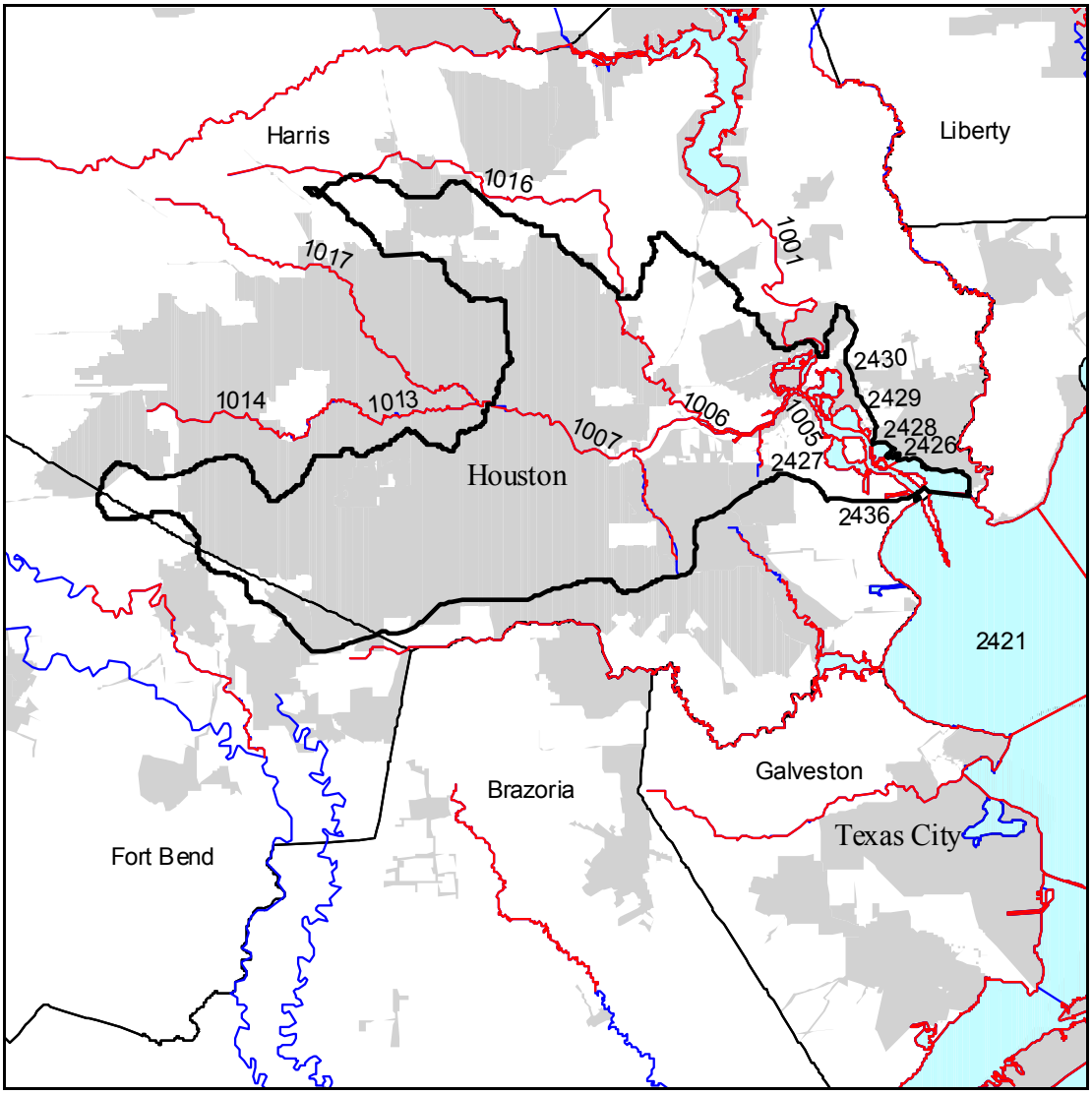

Figure 1. Watershed of the Houston Ship Channel TMDLs

Conservative modeling analyses predicted that potential exceedances of water quality standards could occur in limited areas, although the probability of such exceedances is low. Model simulations of full-permitted discharges under critical low-flow conditions predicted that the marine chronic criterion for nickel could be exceeded in Tucker Bayou, a small tidal tributary of Segment 1006 within a heavily industrialized area, or in a small

area of the San Jacinto River Tidal adjacent to a large industrial discharge. Supplementary model analyses have established that the potential exceedances can be prevented by either reduced effluent limits or relocated discharge points for four permitted dischargers. One discharger on the San Jacinto River Tidal has already voluntarily reduced the permitted load to achieve the needed reduction. Three others on Tucker Bayou have been informed of the situation and will be addressed during pending permit renewal actions.

The loading allocation established by these TMDL analyses will assure that water quality standards for dissolved nickel will continue to be supported and attained in the future.

Endpoint Identification

There are a variety of designated uses assigned to the segments that comprise the Houston Ship Channel System. Designated uses are defined and established in the Texas Surface Water Quality Standards (Texas Water Code §26.023). The following table summarizes the specific designated uses for each of the segments included in the TMDL analyses.

Segment Number and Name	Designated Uses
Segment 1001: San Jacinto River Tidal	Contact Recreation High Quality Aquatic Life Uses
Segment 1005: Houston Ship Channel / San Jacinto River	Noncontact Recreation High Quality Aquatic Life Uses
Segment 1006: Houston Ship Channel	Navigation and Industrial Water Supply
Segment 1007: Houston Ship Channel / Buffalo Bayou	Navigation and Industrial Water Supply
Segment 1013: Buffalo Bayou Tidal	Contact Recreation Intermediate Quality Aquatic Life Uses
Segment 1014: Buffalo Bayou Above Tidal	Contact Recreation Limited Quality Aquatic Life Uses
Segment 1016: Greens Bayou Above Tidal	Contact Recreation Limited Quality Aquatic Life Uses
Segment 1017: Whiteoak Bayou Above Tidal	Contact Recreation Limited Quality Aquatic Life Uses
Segment 2426: Tabbs Bay	Contact Recreation High Quality Aquatic Life Uses
Segment 2427: San Jacinto Bay	Contact Recreation High Quality Aquatic Life Uses
Segment 2428: Black Duck Bay	Contact Recreation High Quality Aquatic Life Uses

Segment Number and Name	Designated Uses
Segment 2429: Scott Bay	Contact Recreation High Quality Aquatic Life Uses
Segment 2430: Burnett Bay	Contact Recreation High Quality Aquatic Life Uses
Segment 2436: Barbours Cut	Contact Recreation High Quality Aquatic Life Uses

Numerical criteria are established for specific toxic substances in the Texas Surface Water Quality Standards Section 307.6. For aquatic life protection, the numerical criteria for specific toxic substances apply to total recoverable concentrations, except for designated metals which apply to dissolved concentrations. Nickel is one of the metals for which the numerical criteria are defined in terms of dissolved concentrations.

Dissolved nickel criteria for marine (saltwater) aquatic life are generally applied to all tidal water bodies. In the Houston Ship Channel System, marine criteria for dissolved nickel are the most limiting and critical water quality standards, and are the same for all marine waters.

Dissolved Nickel Criterion for Saltwater / Marine Waters		
Segment / Water Body	Marine Chronic Criterion (µg/L)	Marine Acute Criterion (µg/L)
All marine / tidal waters	13.2	119.0

The TNRCC has recently adopted revised water quality standards that will become effective upon approval by EPA. The revised marine chronic nickel criterion will be 13.02 µg/L.

The freshwater chronic criterion for dissolved nickel is calculated by:

$$\text{Freshwater chronic criterion} = e^{(0.8460[\ln(\text{hardness})] + 1.1645)}$$

The freshwater acute criterion for dissolved nickel is calculated by:

$$\text{Freshwater acute criterion} = e^{(0.8460[\ln(\text{hardness})] + 3.3612)}$$

Hardness (mg/L as $CaCO_3$) values to be used are the (lower) 15th percentile and are shown in the Implementation Procedures document. The calculated freshwater chronic and acute criteria for selected segments are as follows:

Dissolved Nickel Criteria for Freshwater (including tributaries of saltwater segments)			
Segment	Hardness (mg/L as $CaCO_3$)	Chronic Criterion (µg/L)	Acute Criterion (µg/L)
1001	40	73	653
1005	632	750	6,748
1006	392	500	4,505
1007	100	158	1,418
1013	47	83	749
1014	32	60	541
1016	56	97	868
1017	33	62	555
2426	115	177	1,596
2427	356	462	4,152
2428	873	986	8,868
2429	873	986	8,868
2430	873	986	8,868
2436	873	986	8,868

These TMDLs are designed to achieve and maintain the most stringent of the nickel criteria described above, which is the marine chronic criterion of 13.2 µg/L. The allocation will also achieve and maintain the slightly more stringent marine chronic criterion of 13.02 µg/L that will become effective upon EPA approval of the revised water quality standards.

Source Analysis

Point Sources

There are more than 530 permitted point source discharges to the HSC system, ranging from very small to very large domestic wastewater facilities and including numerous industrial facilities of various types. The TMDL analysis included all permitted continuous discharges except once-through cooling water, which are not expected to measurably alter intake concentrations and would generally be able to comply with the no net additional pollutant loading required by the Water Quality Standards. Intermittent discharges, primarily storm water outfalls, still have to meet the acute water quality criterion for nickel, at a minimum, but would only constitute a very small fraction of the total loading.

Analysis assumed that all continuous discharges contained some amount of nickel, although the great majority are so low in nickel that they have no specific permit limit for

it. Those few dischargers with significant nickel concentrations and permit limits were analyzed using the permitted limits. Industrial discharges without nickel limits in their permits were presumed to have effluent concentrations corresponding to the current marine chronic criterion of 13.2 µg/L, while domestic wastewater discharges were presumed to have effluent nickel concentrations of 5.0 µg/L (½ of the minimum analytical limit of 10 µg/L).

Nonpoint Sources

Analysis of the dissolved nickel conditions focused on a low-flow critical condition, because watershed runoff is expected to be a very minor source of nickel loading that occurs only during periods of high diluting flow. Problematic concentrations of nickel are most likely to occur during low flow conditions when point sources provide most of the net non-tidal flow and pollutant loading. Sites most likely to provide significant nickel loading in surface runoff are generally included in storm water permits, which would only constitute a very small fraction of the total loading.

Background

Analysis assumed that headwater flow into the HSC system during critical low-flow conditions would have a dissolved nickel concentration of 0.4 µg/L, based on samples collected from the San Jacinto River just downstream from the Lake Houston dam. The loading calculated from the net headwater flow used in modeling and the presumed headwater concentration of nickel comprises the entire nonpoint source allocation under the critical low-flow conditions on which these TMDLs are based.

Because the HSC system is tidal, a lower boundary condition for the model is also needed. The analysis assumed a lower boundary dissolved nickel concentration of 1.6 µg/L at Channel Marker 75 in Upper Galveston Bay. Lower boundary conditions affect model results but are not used in calculating watershed loading.

Linkage Between Sources and Receiving Water

The model used for these TMDL analyses is QUAL-TX, a well-defined tool for steady-state water quality modeling. The TEX-TOX model is also used for analyzing individual permit actions, and will continue to have a role as these TMDLs are implemented. QUAL-TX analyses coordinated with TEX-TOX analyses will assure that cumulative effects will not cause exceedances of the water quality criteria.

The QUAL-TX model used physical characterization of the HSC system as developed during the 1980's when a previous TMDL addressed dissolved oxygen conditions in the same water bodies. Nickel data collected during the mid-1990's, using modern clean techniques, was used in conjunction with permitted discharge flows to characterize existing loading. All discharges were presumed to have some nickel concentration. Nickel was simulated using the QUAL-TX generic “non-conservative material” capability. The model setup received EPA technical approval before this TMDL report was completed.

The model analyses indicated that the HSC could potentially assimilate much more nickel than is currently discharged, if discharges are geographically distributed appropriately.

Only one small tributary, Tucker Bayou, was predicted to potentially exceed the marine chronic criterion under the extreme discharge conditions portrayed in the critical condition low-flow model. The TMDL analyses identified allowable loadings for the few dischargers that affect Tucker Bayou. Alternatively, those dischargers could divert their effluents to other outfall locations to meet criteria with their currently permitted loading.

The maximum allowable loading in all other parts of the HSC system cannot be precisely defined now because it would depend on the relative locations and loadings of any new or increased sources. For that reason, *these TMDLs specifically allocate nickel loading sufficient to account for all existing sources with some allowance for growth, but, except in Tucker Bayou, there is a large amount of potentially usable loading capacity remaining unallocated at this time.*

Model analyses for the Houston Ship Channel System TMDL for dissolved nickel were based on a critical condition scenario that combined minimum baseflow in the receiving waters with maximum discharge rates from point sources. Season-specific scenarios would vary from the critical condition scenario due to seasonal differences in baseflow conditions, water temperature, possible seasonal variations in discharge rates, and seasonal differences in water quality criteria. The minimum baseflow values used in the critical condition scenario were based on analyses of annual minima to determine the seven-day two-year (7Q2) low flow, and thus represent the minimum likely to occur during any season of any year. Seasonal temperature variations would not affect the model results, since temperature has very little effect, if any, on the conservative material mass balance or settling rate calculations within the model. Maximum discharge rates are based on permit limits, which are not seasonally variable. Water quality criteria for nickel do not vary by season, so the same criteria are applicable to any seasonal scenario. Therefore, the critical condition scenario used for the TMDL is equally representative of all seasons, and represents the most limiting conditions during any season. Consequently, additional season-specific analyses were deemed unnecessary.

Margin of Safety

A significant but unquantifiable margin of safety (MOS) is implicit in these TMDLs due to the following conservative aspects of the modeling and analysis:

- Total nickel loading, as authorized by permit limits, was modeled as dissolved nickel and assessed against dissolved nickel criteria. In the water column, dissolved nickel concentrations will normally be less than total nickel concentrations, and cannot be greater.
- Model analyses simulated maximum permitted discharge and loading with minimal baseflow to provide dilution. This maximizes the predicted impact of discharges, and provides an allocation that is protective under conditions with an extremely low probability of occurrence.
- The remaining unallocated loading capacity is much greater than the total load allocated in this TMDL report. That fact alone provides a remarkable amount of implicit MOS. Precise calculation of the maximum allowable loading is not feasible at this time, because the spatial distribution and relative magnitude of

potential discharges would determine where and when localized exceedances might occur.

Loading Allocations

Enumeration and counting of TMDLs for tracking and reporting purposes considers each combination of one water body and one pollutant as one TMDL. This document discusses TMDL allocations for a single pollutant (dissolved nickel) for 14 designated segments (water bodies), but describes a single project. Combining multiple TMDLs into single projects allows a more holistic and integrated assessment of pollutant effects and necessary management measures. Singular tense references to "the TMDL" are used within this document for the sake of clear communication regarding this singular project. However, for purposes of satisfying Clean Water Act requirements, this single project and document constitutes 14 individual TMDLs, and will be counted that way for reporting purposes.

These TMDLs specifically allocate nickel loading sufficient to account for all existing sources with some margin of safety and allowance for growth. Except for Tucker Bayou, there is a large amount of potentially usable loading capacity remaining unallocated at this time. The unallocated loading capacity provides a significant but implicit margin of safety for this allocation. Modern clean data have indicated that nickel criteria are being met in the HSC system. Any exceedances that may have occurred historically were apparently very localized and/or of short duration – but there is significant doubt that any such exceedances ever truly existed.

The amount of nickel loading allocated at this time is 148.1184 lbs/day. Expressed in the standard TMDL equation, the total allocation for all 14 segments is distributed as:

LA	+	WLA	+	AFG	=	TMDL
0.1810	+	**101.2608**	+	**46.6766**	=	**148.1184 lbs/day**

Because this is a critical condition low-flow allocation, the nonpoint loading shown is allocated entirely to background sources.

The waste load allocation (WLA) shown above incorporates all currently permitted nickel loading, plus the assumed loading from sources not known to be discharging nickel.

The allowance for future growth (AFG) shown above is included in case it is needed in the near term. The AFG is taken from the unallocated loading capacity, but represents only a small part of it. Reallocation of the AFG to specific permits will be reviewed using the QUAL-TX model to assure that the location or magnitude of the discharges will not cause cumulative exceedance of the water quality criteria.

A Technical Support Document was developed and made available to the public during the public comment period and is hereby incorporated as supporting information for the TMDL calculation.