CITY OF NOVI CITY COUNCIL
JANUARY 6, 2025

SUBJECT: Consideration to Adopt Resolution Consenting to Improvements to Portions of Oakland County's Huron Rouge Sewage Disposal System (HRSDS) and Authorizing Payment to the Oakland County Water Resources Commissioner (WRC) for Same.

SUBMITTING DEPARTMENT: Department of Public Works, Water and Sewer Division

KEY HIGHLIGHTS:

- A sewer interceptor is a large transmission pipe that receives wastewater from other pipes and directs it to a wastewater treatment facility or to another interceptor
- HRSDS Interceptor Sewer is owned by Oakland County, but maintenance, repair, and rehabilitation are funded by Novi
- Sewer is 50+ years old, and inspection identified significant pipe defects
- $19.3M cost estimate - $6M WRC Operating Reserves, $7.3M WRC-issued Bond, $6M Novi Water & Sewer Fund Reserves

FINANCIAL IMPACT

	FY 2024/25
EXPENDITURE REQUIRED	**$ 6,000,000**
BUDGET **Water & Sewer Fund 592-536.00-976.194**	**$ 6,000,000**
APPROPRIATION REQUIRED	**$ 0**
FUND BALANCE IMPACT	**$ 0**

BACKGROUND INFORMATION:

The Huron Rouge Sewage Disposal System (HRSDS) Sewer Interceptor, constructed in 1970, is owned and maintained by the Oakland County Water Resources

Commissioner (WRC). However, since the sewer serves Novi only, the City is by existing contracts responsible for funding all operation and maintenance efforts. The interceptor is the primary receiving sewer for the HRSDS district, which serves the great majority of Novi (south of 12 ½ Mile). The attached map shows the location of the HRSDS sewer and shows portion of the interceptor to be rehabilitated between I-96 and Chattman Street, referred to as the Novi Trunk Extension No. 1.

In 2019 WRC performed a closed-circuit television inspection (CCTV) of the sewer interceptor as part of its SAW Grant activities. This segment was identified as a high priority for rehabilitation, due to the severity of defects and high incidence of failure (identified from the inspection as including gushing/running/weeping infiltration; missing, projecting, and visible aggregate; and surface spalling). In 2022 WRC engaged NTH Consultants, for a proposal to evaluate and recommend a rehabilitation strategy. NTH released its draft report in October 2023. The attached November 15, 2023, final report provides details of the inspection results and rehabilitation recommendations to WRC as a basis for designing the project.

This rehabilitation project as designed includes approximately 16,700 feet of 36-inch diameter concrete pipe and consists of various methods of internal pipelining to restore structural integrity and eliminate leaks. The location of this sewer presents challenges, including environmental sensitivity and alignment adjacent to the railway (and along the Walled Lake Branch of the Middle Rouge), making access difficult. Additionally, significant bypass pumping of existing flow is required to isolate the segments to complete repairs. The project will be difficult and lengthy, but the repair methods are intended to provide a long-life span.

Following a public bidding process, WRC awarded the project to SAK Construction, the sole bidder. As detailed in the attached project estimate, the total cost is estimated to be $19.3M. WRC will use $6M from their Operating Fund Reserves. $7.3M will be bonded by WRC. This Resolution authorizes the remaining and required $6M to be paid by the City from its Water & Sewer Fund reserves. The City Attorney has reviewed and approved the attached Resolution for the City's payment.

The current schedule for the project anticipates completion in approximately one year, and construction activity is underway now.

RECOMMENDED ACTION: Consideration to Adopt Resolution Consenting to Improvements to Portions of Oakland County's Huron Rouge Sewage Disposal System (HRSDS) and Authorizing Payment to the Oakland County Water Resources Commissioner (WRC) for Same.

CITY OF NOVI

COUNTY OF OAKLAND, MICHIGAN

RESOLUTION CONSENTING TO IMPROVEMENTS TO PORTIONS OF THE HURON ROUGE SEWAGE DISPOSAL SYSTEM (HRSDS) AND AUTHORIZING PAYMENT TO THE OAKLAND COUNTY WATER RESOURCES COMMISSIONER (WRC) FOR SAME.

Minutes of a Meeting of the City Council of the City of Novi, County of Oakland, Michigan, held in the City Hall of said City on January 6, 2025 at 7 o'clock P.M. Prevailing Eastern Time.

PRESENT: Councilmembers_____

ABSENT: Councilmembers_____

The following preamble and Resolution were offered by Councilmember _____ and supported by Councilmember _____.

RECITALS

WHEREAS, the Huron-Rouge Sewage Disposal System (the "HRSDS") is a system of sanitary sewage disposal improvements and services established by the County of Oakland (the "County") and located within the City of Novi (the "City") to serve the City; and

WHEREAS, the County acquired and constructed the HRSDS facilities pursuant to the Huron-Rouge Sewage Disposal System Contract dated as of April 20, 1962, among the County, the Village of Novi, and the Township of Novi, as amended (the "Contract"); and

WHEREAS, the County owns and operates the HRSDS pursuant to the Contract, and has designated the Oakland County Water Resources Commissioner as the county agency (the "County Agency") for the HRSDS with all powers and duties with respect thereto as are provided by, Act 342, Public Acts of Michigan, 1939, as amended; and

WHEREAS, the County Agency conducted closed-circuit television inspections of the HRSDS and identified the presence of structural defects needing rehabilitation in portions of the HRSDS; and

WHEREAS, the County Agency has undertaken efforts to begin rehabilitation of the HRSDS, such rehabilitation to consist of structural rehabilitation and installation of

pipelining for approximately 16,700 lineal feet of sanitary sewer system interceptor infrastructure and related structures and facilities in the HRSDS, as well as all work, equipment, and appurtenances necessary or incidental to these improvements, including without limitation the restoration of property, streets, rights-of-way, and easements affected by the improvements, and such other HRSDS improvements as the County Agency shall determine to make to the portions of the HRSDS depicted on the map attached hereto as Exhibit A (the "Improvements"); and

WHEREAS, the total estimated cost of the Improvements is $19,470,000; and

WHEREAS, the County Agency has received bids and awarded a contract for acquisition, construction, and installation of the Improvements; and

WHEREAS, the County has issued bonds in the amount of $7,470,000 to finance a portion of the Improvements for the benefit of the County and its residents in the City; and

WHEREAS, HRSDS operating reserves held by the County Agency will be applied in the amount of $6,000,000 to pay a portion of the Improvements; and

WHEREAS, the City has determined to make a cash contribution in the amount of $6,000,000 from the City's Water & Sewer Fund reserves on hand and lawfully available therefor in order to pay a portion of the costs of the Improvements and the County Agency has presented an invoice requesting payment therefor.

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Novi, Oakland County, Michigan, that:

1. The City, in accordance with Section 29, Article VII, Michigan Constitution of 1963, consents and agrees to the establishment and location of the Improvements within its corporate boundaries and to the use by the County of its streets, highways, alleys, lands, rights-of-way or other public places for the purpose and facilities of the Improvements and any improvements, enlargements or extensions thereof.

2. The Improvements shall consist of improvements to portions of the HRSDS as shown and described on Exhibit A, which is attached hereto and is made a part hereof.

3. A to the County Agency in the amount of $6,000,000 from Water & Sewer Fund reserves is hereby approved and shall be paid by not later than January 15, 2025 to the County of Oakland as invoiced by the County Agency.

AYES:

NAYS:

RESOLUTION DECLARED ADOPTED.

_____
Cortney Hanson, City Clerk

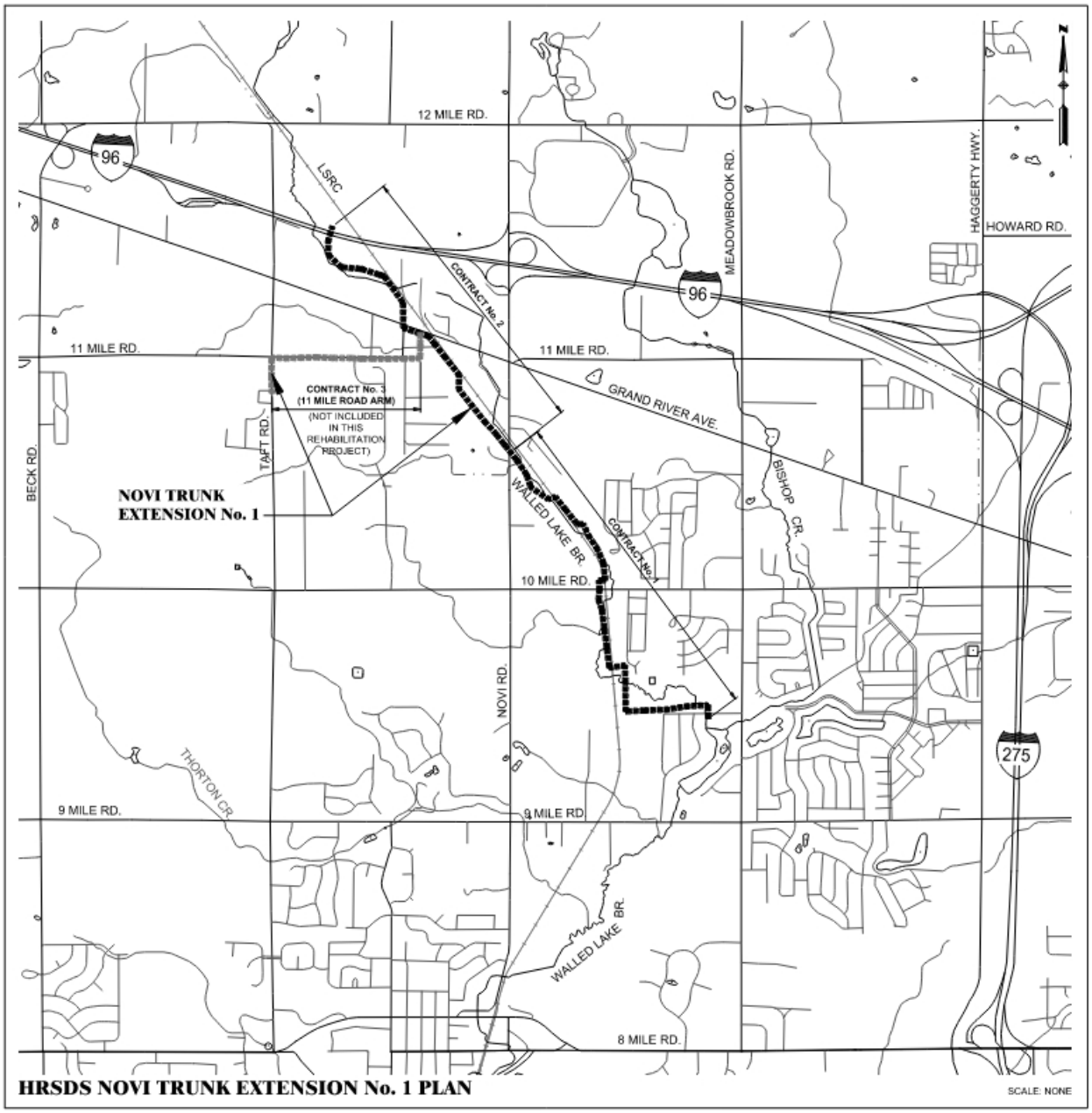
CERTIFICATION

I hereby certify that the foregoing is a true and complete copy of a resolution adopted by the City Council of the City of Novi, County of Oakland, and State of Michigan, at a regular meeting held this 6th day of January, 2025, and that public notice of said meeting was given pursuant to and in full compliance with Act No. 267, Public Acts of Michigan, 1976, and that the minutes of said meeting have been kept and made available to the public as required by said Act.

_____
Cortney Hanson, City Clerk
City of Novi

EXHIBIT A

Map Depicting Portions of HRSDS to be Improved



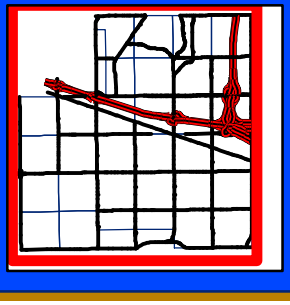
HRSDS Sewer Interceptor

WRC Owned and Maintained Sewer

Map Author: Croy
Date: Nov 2024
Project: HRSDS Sewer
Version #: v1.0

MAP INTERPRETATION NOTICE

Map information depicted is not intended to replace or substitute for any official or primary source. This map was intended to meet National Map Accuracy Standards and use the most recent, accurate sources available to the people of the City of Novi. Boundary measurements and area calculations are approximate and should not be construed as survey measurements performed by a licensed Michigan Surveyor as defined in Michigan Public Act 132 of 1970 as amended. Please contact the City GIS Manager to confirm source and accuracy information related to this map.



City of Novi
Engineering Division
Department of Public Works
26300 Lee BeGole Drive
Novi, MI 48375
cityofnovi.org

Feet
0 875 1,750 3,500 5,250

1 inch = 4,280 feet

HRSDS Sewer Lining Project
ESTIMATE OF TOTAL PROJECT COSTS
REVISED: 10/21/2024

		Project Costs
1)	**Facility Acquisition**	
a	Construction Cost	$ 13,868,526
	Subtotal Facility Acquisition	**$ 13,869,000**
2)	**Engineering Consultants**	
a	Prelim. Engineering (Study) and Design Phase Services	$ 1,047,771
b	Construction Phase Services Incl. Materials Testing	$ 1,127,218
c	Scheduling Consultant	$ -
d	Additional Special Services	$ -
	Subtotal Engineering Consultants	**$ 2,175,000**
3)	**Project Financing & Legal**	
a	Project Insurance	**$ 781,000**
b	Bond Issuance (Legal)	**$ 32,575**
c	Bond Issuance (Financial Consultant)	**$ 166,000**
d	Wetland Mitigation	**$ -**
	Subtotal Project Financing & Legal	**$ 980,000**
3)	**Right of Way**	
a	Easement Fees	$ 25,000
b	Legal Fees	$ -
c	Permits	$ -
d	County Services	$ 117,128
	Subtotal Right of Way	**$ 142,000**
4)	**Exclusive County Services**	
a	Administration	$ 102,268
b	Engineering	$ 197,071
c	Inspection	$ 112,067
d	Survey	$ -
e	O&M Startup	$ 11,205
	Subtotal Exclusive County Services	**$ 423,000**
8)	**Project Subtotal**	**$ 17,589,000**
9)	**Project Contingency (10%)**	**$ 1,759,000**
10)	**Total Project Cost**	**$ 19,300,000**
	Novi Cash Contribution	6,000,000
	WRC Novi Operating Fund Reserves	6,000,000
	Bonds	7,300,000

WRC
WATER RESOURCES COMMISSIONER
Jim Nash

December 20, 2024

Mr. Ben Croy, P.E.; City Engineer
City of Novi Department of Public Works
26300 Lee BeGole Drive
Novi, Michigan 48375

RE: Huron Rouge Sewage Disposal System Lining Project Invoice Request

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Dear Mr. Croy,

The HRSDS is a sanitary sewer network owned and operated by the OCWRC and located in the City of Novi. The HRSDS Novi Trunk Extension No. 1 extends from the north side of Interstate Freeway I-96 and east of Taft Road to Chattman Street north of 9 Mile Road in Novi, Michigan. This section of the HRSDS was originally built under three construction contracts in 1970. Based on the 2019 closed-circuit television (CCTV) inspections of the Novi Extension No. 1, a majority of the reaches in Contracts No. 1 and No. 2 have structural defects identified that present long-term concern of the structural integrity of the sewer pipe. To address these conditions, the HRSDS Rehabilitation Project has been developed to reline these reaches. Contract No. 3, also called the Eleven Mile Arm, is a smaller 12-inch diameter sewer, and is not included in the rehabilitation scope of this project.

The project has been bid and the selected bidder is SAK Construction, LLC in the amount of $13,868,526. The project estimate with the low bid is $19,470,000. Per our contract, the City is responsible for all costs related to the system including this project. The Novi sewer reserve account held by WRC will be used to fund a $6,000,000 portion of the project. Bonds have been sold to fund a $7,470,000 portion of the project. Payment of the remaining $6,000,000 project cost by the City is required. The WRC has submitted an invoice to the City for this amount. Also, a Resolution has been provided for City Council approval. Please let me know if you need anything else for City Council for consideration of the requested payment. We look forward to completing this project.

Please contact me at 947-955-6560 with any questions.

Sincerely,

Jen Cook, P.E.
WRC Assistant Chief Engineer

INVOICE

Oakland County
WRC Water and Sewer
1200 N Telegraph
Pontiac, MI 48341

Customer ID: CU000477
Invoice Number: CI048413
Invoice Date: 11/14/2024
Due Date: 12/14/2024
Amount Due: USD 6,000,000.00

Bill To:

CITY OF NOVI
FINANCE DEPT, #592
45175 W 10 MILE RD
NOVI, MI 48375-3024

For billing questions, please call: Brenda Reyes-Mezza at 248-858-0134
Email: reyesmezzab@oakov.com

Description - Goods and Services	Quantity	UOM	Unit Price	Amount
Reimbursement General, Contribution to HRSDS Sewer Lining Project #17079	1	Each	6,000,000.00	6,000,000.00

Sub Total	**6,000,000.00**
Tax	**0.00**
Invoice Total	**6,000,000.00**

PLEASE INCLUDE YOUR INVOICE NUMBER WHEN SUBMITTING PAYMENT.

Payment can be made to Oakland County Treasurer's Office via credit card at 248-858-0638 Monday-Friday 8:30AM-4:30PM.
Please have your Invoice Number ready when calling in payment.

Payment can also be made via check made payable to Oakland County Treasurer.
Please reference your invoice number on the check. Mailing address: 1200 N. Telegraph Rd. Bldg 12E, Pontiac, MI 48341.

Please Remit Payments to:

Oakland County
Treasurers-Cash Acctg Bldg 12 E
1200 N Telegraph
Pontiac, MI 48341
United States of America

BASIS OF DESIGN REPORT

HURON ROUGE SEWAGE DISPOSAL SYSTEM (HRSDS)

Novi Trunk Extension No. 1 Sewer Rehabilitation Project

Oakland County
Water Resources
Commissioner's Office

November 15, 2023
NTH Project No. 22000562

NTH Consultants, Ltd.
41780 Six Mile Road
Suite 200
Northville, MI 48168

NTH Consultants, Ltd.
Infrastructure Engineering
and Environmental Services

41780 Six Mile Rd., Suite 200; Northville, MI 48168
Phone 248-553-6300• Fax 248-324-5179

Ms. Jennifer Cook, P.E.
Civil Engineer III
Office of the Oakland County Water Resources Commissioner
One Public Works Drive, Building 95 West
Waterford, MI 48328-1907

November 15, 2023
NTH Project No. 22000562

RE: Basis of Design Report
Huron Rouge Sewage Disposal System (HRSDS)
Novi Trunk Extension No. 1 Rehabilitation Project
Oakland County, Michigan

Dear Ms. Cook:

In accordance with our proposal, we have completed the Basis of Design report for the HRSDS Novi Trunk Extension No. 1 Rehabilitation Project. This report presents our evaluations and recommendations regarding sewer rehabilitation. Information gathered during the investigation and exploration phases of the project are included as appendices to this report and aided in development of appropriate rehabilitation methods recommended for the sewer.

We appreciate this opportunity to be of service to you and trust the information provided in the attached report is sufficient for your present needs. Upon your review, should you have any questions or comments, please feel free to contact us.

Sincerely,

NTH Consultants, Ltd.

DocuSigned by:
Joel Schanne
C80DC847382B419...

Joel Schanne, P.E.
Senior Project Engineer

DocuSigned by:
Saju Sachidanandan
04261F17B85445C...

Saju Sachidanandan, P.E.
Project Manager

JDS/SS/mlk

Attachments

cc: Joel Brown, P.E – OCWRC Chief Engineer
Drew Sandahl, P.E - OCWRC Chief Engineer

EXECUTIVE SUMMARY

This executive summary provides a general overview of the basis-of-design (BOD) report on the Huron Rouge Sewage Disposal System (HRSDS) Novi Trunk Extension No. 1 Sewer Rehabilitation project. This BOD presents our evaluations and recommendations for rehabilitating the sewer reaches within the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2. The discussion and conclusions provided herein should be considered together with and in the context of the overall project. Throughout this report, this project will be referenced as the "HRSDS Rehabilitation Project".

The HRSDS Novi Trunk Extension No. 1 extends from the north side of Interstate Freeway I-96 and east of Taft Road to Chattman Street north of 9 Mile Road in Novi, Michigan. This section of the HRSDS was originally built under three (3) construction contracts in 1970 – Contract No. 1, Contract No. 2, and Contract No. 3. Based on the 2019 closed-circuit television (CCTV) inspections of the Novi Extension No. 1, a majority of the reaches in Contracts No. 1 and No. 2 have structural defects identified. The distress noted during the inspection included loss of concrete pipe thickness resulting from microbial-induced-corrosion (MIC). The observed pipe defects included gushing infiltration, running infiltration, weeping infiltration, aggregate projecting, aggregate missing, aggregate visible, and surface spalling. Moreover, the noted structural defects such as aggregate visible, projecting, and missing, as well as concrete surface spalling are observed over long continuous lengths within the reaches and indicate an incremental thinning of the concrete pipe wall. These defects present long term concern of the structural integrity of the sewer pipe. In order to address these conditions, the proposed HRSDS Rehabilitation Project has been developed to consist of the relining of the reaches of sewer under Contract No. 1 and No. 2. The third contract (Contract No. 3), also called the Eleven Mile Arm, is a smaller 12-inch diameter sewer, and is not included in the rehabilitation scope of this project.

The sections of HRSDS Novi Trunk Extension No. 1 Contract No. 1 and Contract No. 2 identified for rehabilitation are constructed of 36-inch diameter precast reinforced concrete pipe and are approximately 16,700 feet in combined length. These reaches have a total of forty-nine, 4-foot diameter access manholes, and numerous lateral connections along the alignment as well as at manholes. Based on historical records, the sewer was constructed using predominantly "open-cut" methods, and the alignment roughly parallels a railroad owned by CSX Transportation, Inc. (CSX) and operated by the Lake State Railway Company (LSRC). However, note that an "in-tunnel" construction method was adopted at locations where the sewer alignment crosses roads, and a "jack and bore in casing" construction technique was adopted in areas where the sewer crossed under railroads. In addition to the sewer being in the vicinity of LSRC right-of-way (ROW) and the Walled Lake Branch of the Rouge River, the alignment runs through environmentally sensitive areas including wetlands, woodlands, and is surrounded by residential, commercial, and industrial developments. Historical subsurface exploration reveals that most of the existing sewer appears to have been constructed through granular and cohesive deposits. In all cases, the observed historical groundwater was at elevations above or within the sewer levels.

The HRSDS Novi Trunk Extension No. 1 is a unique project that will be constructed in challenging right-of-way environments, flow control, and underground conditions. As such, as part of this rehabilitation project, we considered the following to evaluate the construction feasibility:

- Sewer replacement by installing new pipe or pipe bursting techniques; and
- Rehabilitation using spray-on coating, grout-in-place liner (GIPL), slip-lining, tight-fit liners, and cure-in-place pipe (CIPP) techniques.

Due to the significant costs associated with obtaining new easements, installing new manholes, relocating tap connections and other nearby utilities, dewatering, clearing and constructing access roads through protected woodlands/wetlands, and required bypass pumping, we believe that rehabilitation of the existing host pipe is the more cost effective and less disruptive option when compared to constructing new sewer. Considering the alignment of the sewer and its proximity to existing utilities and surface features, pipe bursting efforts could disrupt nearby utilities along with the potential to cause heaving underneath major road and railroad crossings. Additionally, the railroad crossings in which steel casings were installed and the pipe was jacked underneath the railroad, would not be possible to burst. Moreover, this method will result in additional cost and site disturbances to the project, including full bypass requirements, reinstating lateral taps, and easement acquisition, that we do not feel is necessary since the current hydraulic analysis demonstrates that increased flow capacity is not required. As such, pipe bursting is not a recommended option.

As part of rehabilitation study, a total of 18 sewer lining products were evaluated. Further, the liner evaluations narrowed the viable rehabilitation solutions down to 12 products that showed potential of performing well within the HRSDS environment and that were adaptable to the difficult construction constraints within the sewer. For each of the rehabilitation options, various parameters were considered including strength requirements, constructability/risks involved, access to install the liners, environmental disturbance, long-term liner performance, hydraulic impacts, cost, schedule, and other pertinent criteria.

Spray-on liners and GIPL were initially considered but were eliminated from further consideration for this project due to a variety of factors. The performance of the spray-on/coating liner systems are highly dependent on the condition of the substrate (host pipe) to which they are applied. Providing a clean substrate and low-humidity environment with 100% bypass pumping is very costly for installation of spray-on liners, especially for the total length of sewer to be rehabilitated under this project. GIPL systems also require an adequate bond with the host pipe, as they rely on composite strength between the host pipe, structural grout, and the inner liner material. Rags and debris getting behind liner sections that have not yet been grouted is a major concern for GIPL systems that require a full thickness structural grout and strong mechanical bond with the existing host pipe to achieve a structurally sound liner. Moreover, full bypass pumping will be required during the GIPL installation process in order to efficiently install the liner and keep the annular space clean for grouting.

Even considering the costly bypass pumping operations, desire to limit environmental disturbances, and the construction of access shafts, it became apparent during the study that there are multiple slip-lining, tight-fit lining, and CIPP liner products that can be effectively utilized to rehabilitate the sewer. However, due to the diameter size constraints and other design limitations, not all of the sliplining products were recommended. Refer to the recommendation section of this report for details of the "pre-selected" slip-lining, tight-fit lining, and CIPP liner products.

Based on this BOD study, we recommend the following for consideration during the design phase of the project:

- Based on the evaluation of the current condition of the sewer, a structural rehabilitation of the sewer is recommended for the entire alignment. Considering the hydraulic capacity requirements of the system, the maximum cross-sectional reduction of the sewer after rehabilitation shall be limited to 26 inches in internal diameter. However, the final finished diameter shall be optimized in the design phase to provide the maximum allowable diameter to allow for future capacity needs.
- Based on the hydraulic study, there is no redundancy in the system for sewage diversion during rehabilitation. As such, bypass pumping will be required for rehabilitation options that require no flow in the sewer. The diameter of the discharge line will be dependent on the operating curves of the selected pumps but most likely will range from 6 to 15 inches.
- Considering the alignment of the sewer running through various commercial, residential, and industrial developments, the acquisition of construction easements for laydown areas, bypass piping, as well as access roads will require advance planning and potentially long lead times to secure legal descriptions and agreements.
- Multiple governmental agencies and private parties will have to be coordinated during the design and construction phases of the project. This is critical to avoid construction delays and project costs.
- The design shall include any restrictions by the governing agencies related to disturbances to existing regulated wetlands, floodplain, floodway, as well as Threatened and Endangered Species.
- Include up to eight (8) access pits or shafts at "select" locations to allow for lining long reaches of pipe from single access locations to reduce setup time. Since there is uncertainty in the number and location of access shafts required for the various lining options, we recommend that options for easements be negotiated to allow the Owner to exercise the option only if the easement is needed. Furthermore, we recommend obtaining "permanent" easement(s) from public right-of-way to the access shaft locations and maintain an access path for future sewer access and maintenance.
- At the above access shaft locations, install a larger diameter manhole (greater than 4 feet in diameter) in order to provide ease of access for any future work within the system. Also, modify any existing manholes recommended for access during construction by replacing the cone section with a flat top configuration for future access and maintenance.
- Obtain soil and groundwater information including environmental characteristics of the soil at potential access shaft locations. The available historic explorations provided some data such as the types of soils and some limited laboratory testing, but the data is not sufficient for a complete understanding of the subsurface conditions. In consideration of the above, and to confirm and supplement the existing soil data, NTH proposes drilling additional test borings and installing open standpipe monitoring wells at proposed shaft locations to confirm the subsurface soil profile and obtain current groundwater level information as well as develop soil handling/disposal procedures.
- Include as needed sewer cleaning to remove accumulated deposits in the construction contract.
- Include as needed chemical and/or cementitious grouting to address gushing and running sewer infiltrations in the construction contract.
- Include as needed localized concrete sewer repairs to address minor localized concrete spalling, including at manholes, in the construction contract.

- Use one or more slip-lining, tight-fit lining, or CIPP liner product(s) to rehabilitate the 36-inch diameter reinforced concrete pipe for the entire alignment. The final lining products chosen for installation will be based on our evaluation and recommendation as well as the bid process detailed in the project delivery section of this document.
- Develop a bid proposal to encourage maximum participation by "pre-selecting" lining manufacturers for each sewer rehabilitation reach, while providing options for the Project Owner for final decision making. Through this process, each participating liner manufacturer and contractor will have opportunities to increase their participation by selecting/deciding the most cost-effective solution (number of access shafts, bypass requirements, etc.) for each liner reach according to their means and methods.
- As part of the design phase, develop strategies to reduce or eliminate the project risks identified in this report. This may include creating contingency plans, including allowances or pertinent design detail(s)/specification(s) into the contraction contract documents, which helps to minimize disruptions and unexpected project costs.
- Based on our preliminary evaluation, the Engineer's Opinion of Probable Construction Cost estimate for the full rehabilitation scope to be approximately $16.6M – $20.5M (with 20% contingency) and may take approximately 18 months to complete from notice to proceed.

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APPENDICES

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1) Site Reconnaissance and Manhole Scan Memorandum, dated July 5, 2023
2) Manhole Scan Files (*Electronic Format Only)*

Appendix E: HRSDS Novi Trunk Extension No. 1 Plan and Profile Drawings

Appendix F: Geotechnical Exploration Report, dated July 13, 2023

Appendix G: Preliminary Environmental Corridor Study Report, dated July 13, 2023

Appendix H: Threatened and Endangered Species Evaluation Memorandum, dated August 10, 2023

Appendix I: Wetland Delineation Study and Opinion of EGLE Jurisdiction Memorandum, dated August 10, 2023

Appendix J: Preliminary Sewer Rehabilitation Options Drawings

Appendix K: Hydraulic Capacity and Bypass Pumping Analysis Memorandum

Appendix L: Engineer's Opinion of Probable Construction Cost and Construction Schedule

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1.0 INTRODUCTION

In September 2022, Oakland County Water Resources Commissioner's office (OCWRC) retained NTH Consultants Ltd. (NTH) to perform field explorations, engineering design, bidding assistance, and project management services for the rehabilitation of the Huron Rouge Sewage Disposal System Novi Trunk Extension No. 1 Contract Nos. 1 and 2. In order to complete these tasks, NTH formed a project team by procuring the services of Applied Science, Inc. (ASI) to complete the HRSDS hydraulic analysis and bypass pumping design and Anderson, Eckstein, and Westrick, Inc. (AEW) to perform topographical survey, easement study, site civil design, and generate plan and profile drawings. AEW retained the services of Barr Engineering Co. (Barr) to complete the Threatened and Endangered Species (T&E) and Wetland Delineation studies.

This BOD report summarizes our evaluations and recommendations for the rehabilitation of the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2. Specifically, this report presents our evaluations and recommendations of sewer lining options including liner type and location of sewer rehabilitation, repairs for addressing the existing leaks at various locations along the alignment, bypass pumping options and requirements during flow diversion, manhole access and associated easement requirements, as well as potential location and number of access shaft locations along the alignment. For each of the rehabilitation options, various design and constructability parameters were considered during the study such as constructability risk, access options, environmental disturbance, long-term liner performance, hydraulic impacts due to sewer cross sectional reduction, overall project cost and schedule, and other pertinent criteria.

2.0 HISTORY AND PROJECT BACKGROUND

The Novi Trunk Extension No. 1 is part of the OCWRC Huron Rouge Sewage Disposal System running from north of Interstate Freeway I-96 and east of Taft Road to Chattman Street north of 9 Mile Road in Novi, Michigan. The HRSDS is a sanitary sewer network owned and operated by the OCWRC. The HRSDS services local sewers from the cities of Northville and Novi by conveying the flow down to the Parkway Interceptor of the Rouge Valley Sewage Disposal System (RVSDS) which is ultimately conveyed to the Water Resource Reclamation Facility of the Great Lakes Water Authority (GLWA) system. The HRSDS Novi Trunk Extension No. 1 was originally built under three (3) construction contracts in 1970 – Contract No. 1, Contract No. 2, and Contract No. 3. The sections of HRSDS (Contract No. 1 and Contract No. 2) identified for rehabilitation are constructed of 36-inch diameter precast reinforced concrete pipe and are approximately 16,700 feet in combined length. There are a total of 49 access manholes and the sewer invert depth ranges from about 11 to 30 feet below ground surface along this reach. In this report, the manholes are designated with both a sequential numbering system obtained from historical records (ex: MH-1) and Legacy ID (ex: NOT 101001). Contract No. 3, also called the Eleven Mile Arm, is a smaller sewer (12-inch diameter vitrified clay pipe) connected to the Novi Trunk Extension No.1. Note that Contract No. 3 is not part of the subject rehabilitation project. Refer to Figure 1 for details of the HRSDS alignment.

Based on the available as-built records, the Novi Trunk Extension No. 1 was constructed using predominately "open-cut" methods of construction and with the majority of the alignment running approximately parallel to the current LSRC railroad (formerly CSX railroad). Given the size of the sewer, the relatively shallow depth, and the presumed site conditions in 1970 consisting of largely undeveloped areas, it is our understanding that the work most likely proceeded in a traditional open cut manner with sloped sides (generally without temporary shoring). However, it was noted that an

"in-tunnel" method was adopted at locations where the sewer alignment crosses roads, and a "jack and bore in casing" construction technique was adopted in areas where the sewer crossed under the railroad. Details of in-tunnel construction are not available in the project record documents. The jack-and-bore technique involves installation of the permanent carrier-pipe through a casing pipe that is typically augured and jacked into place. Typically, the remaining annular space between the casing and carrier pipe would then be filled with cementitious grout. Details of the casing and annulus grout are not available in the construction records. See the As-Built Record Drawings dated 1970 in Appendix A for additional information.

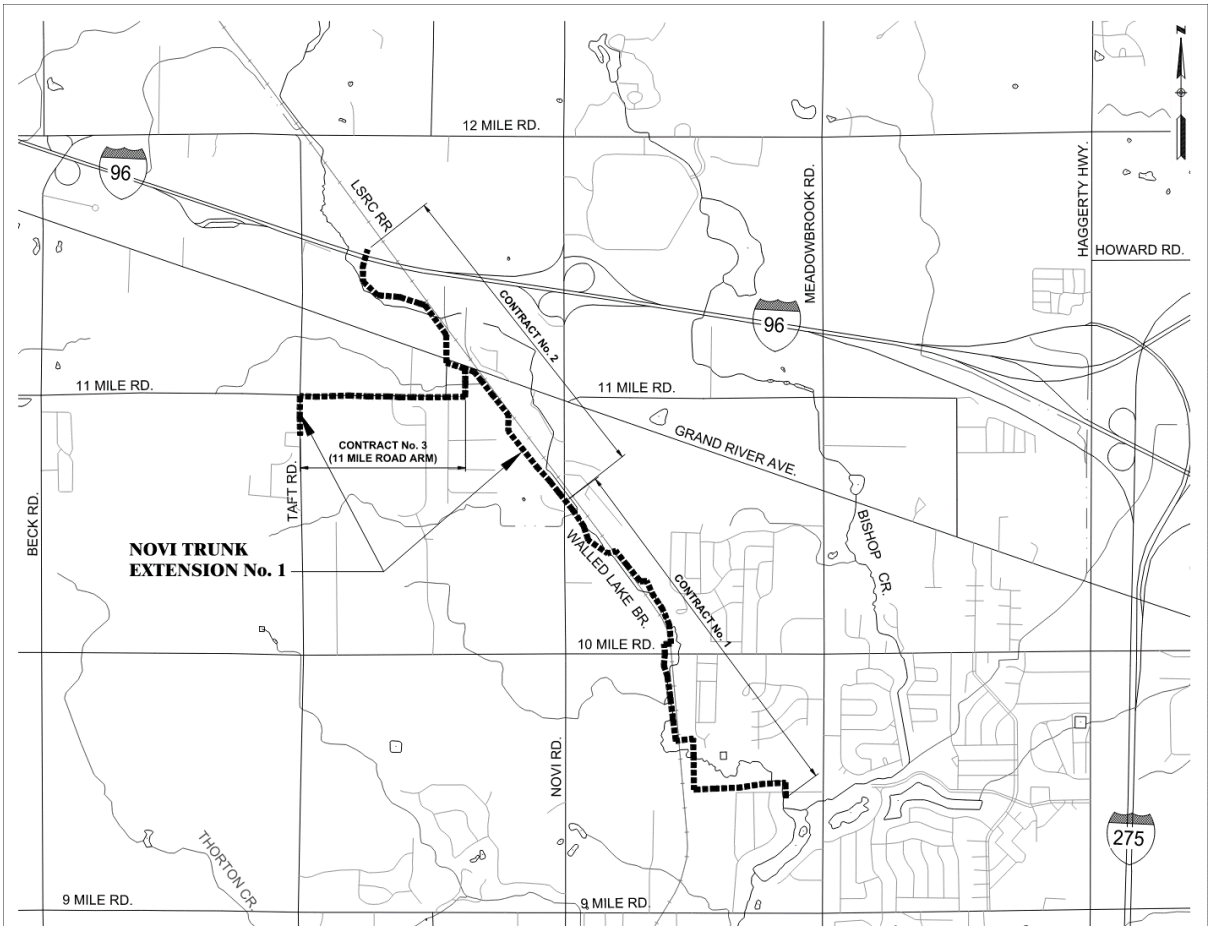


Figure 1: HRSDS Novi Trunk Extension No. 1 Alignment

3.0 CURRENT CONDITIONS

As part of the initial investigation phase, NTH reviewed the available sewer inspection data and historical record information provided by the OCWRC and performed preliminary subsurface explorations as well as field surveys to provide preliminary recommendations for the future rehabilitation design of the affected sewer reaches of the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2. A summary of the current conditions of the sewer, existing easement information, subsurface soil and ground water conditions, environmental site assessment, system hydraulic capacity, and existing wetland as well as threatened and endangered species assessment is given in the following subsections.

3.1 HRSDS CONDITION ASSESSMENT

Inspection of the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2 was completed in the summer of 2019 by an OCWRC contractor using CCTV techniques. As part of the 2019 inspection, the CCTV footage for each of the reaches was reviewed and its operational and structural defects were recorded according to the National Association of Sanitary Sewer Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) standards.

Based on our review, all 48 reaches have some level of structural defects that are related to interior surface deterioration of the concrete pipe and affect continuous lengths of the pipe surface. The most common defects consist of aggregate missing (Grade 4), with aggregate visible (Grade 2) and reinforcement visible (Grade 4) coded as well. Based on the video evidence, these defects appear to be related to MIC. The surface of the concrete pipe appeared soft, and some reaches exhibited small patches where the softened material had sloughed off. The MIC attack on the concrete surface has caused a swelling of the surface layer of affected concrete. Moreover, the reach between manholes NOT 059005 (MH-44A) and manhole NOT 059004 (MH-43) has two sections of precast pipe where there has been enough concrete wall loss that reinforcing steel is visible for a significant portion of the visible pipe circumference. Several reaches have operational and maintenance defects of infiltration such as gushing infiltration (Grade 5) and running infiltration (Grade 4). Furthermore, many of the sewer reaches also had active weeping (Grade 2) and/or dripping (Grade 3) leaks.

Review of the PACP inspection reports and videos showed that there are several sewer reaches along the alignment that include "sag" defects. Due to the surface deterioration of the concrete caused by MIC attack, visual assessment of the joints in these sags is obstructed. Based on what is visible, the joints in these sags do not appear to be significantly open or offset. As a result, it is our opinion that the observed sags are most likely due to original construction conditions or general bedding settlement over time and these sags do not correlate to any active infiltration. The most significant sag is approximately 40 feet long located below 10 Mile Road west of the LSRC railroad. Historical construction drawings indicate that this section of sewer was installed using an "in tunnel construction" technique, and the sag in alignment in this reach is most likely due to original construction conditions.

Six (6) of the reaches have lateral tap connections identified that blind tie directly into the pipe, and 30 of the 49 manholes have tap connections within the manhole. The majority of these taps are active and range from 6 inches to 18 inches in diameter. Several of these taps were identified in the PACP reports as defective. Review of the videos showed that this was attributed to attached deposits or mineral build up, rather than a significant structural defect. The presence of active taps in both the sewer reaches and in manholes will need to be considered during the evaluation of potential repair options. Refer to the CCTV Inspection Reports from OCWRC, included in Appendix B, for additional assessment details.

Evaluations from the condition assessment and subsequent review meetings with OCWRC resulted in recommending chemical grout leak sealing of running and gushing infiltration defects and re-inspection of reaches in "high consequence" areas. High consequence areas included locations where the sewer crosses major roadways and critical utilities. These sewer reaches were re-inspected by OCWRC in December 2022. The purpose of the re-inspection was to determine if immediate repairs or additional leak sealing efforts need to be prioritized while the overall

rehabilitation of the Novi Trunk Extension No. 1 is being evaluated/designed. In general, the condition of the sewer appeared to have remained stable. Overall, the number of infiltration locations remained the same or decreased within each evaluated reach. Further, NTH recommended performing exploratory soil borings at the historic runner/gusher locations in high consequence areas to verify the presence of loose soils/voids around the 36-inch diameter sewer as part of the investigation phase of the rehabilitation design project. See the attached Memorandum "2019 vs 2022 CCTV Comparison Summary at High Consequence Areas", dated June 29, 2023, in Appendix C for additional information. The data obtained during the exploratory soil borings at the historic runner/gusher locations in high consequence areas are summarized in the Subsurface Conditions section of this report.

In May 2023, NTH performed an investigation of the 49 manholes of the system using 360-degree video technology to identify the general configuration of the manhole, the size and location of tap connections within each manhole and reviewed the general conditions of the manholes. The investigation found that the manholes are in generally good condition. All manholes except for MH-44 (NOT 058003) were identified to be standard 48-inch diameter manholes with a cone top section. MH-44 (NOT 058003) has two cone sections and opens into a larger 72-inch diameter manhole. Minor defects that we typically observed across all of the manholes include the following: surface aggregate visible, fine roots barrel, and capped tap connections. Note that manhole MH-29 (NOT 085002) was inaccessible due a stripped bolt in the frame and cover and that manhole MH-38A (NOT 060008) was not located in the field during the manhole evaluations. Upon review of the CCTV inspections, we observed that manhole MH-38A was located on a lateral tap connection at the designated location. Manhole scan files obtained during the investigation along with screenshots of each manhole's invert are attached in Appendix D for reference.

3.2 EXISTING EASEMENTS ALONG SEWER ALIGNMENT

The existing alignment of the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2 is contained within OCWRC property, easements, or ROW. The easements containing the alignment are generally 20 feet in width, with certain areas ranging from approximately 15 feet to 100 feet wide. The locations of the alignment in which the easements are less than the typical 20-foot width and areas where the sewer alignment does not fall within the existing easements are described in the following paragraph.

- Starting at the northern and upstream end of the alignment and moving downstream, the sewer crosses underneath the I-96 freeway ROW from MH-45 (NOT 058002) to MH-44 (NOT 058003). The easement between MH-44 to MH-44A (NOT 059005) extends south approximately 25 feet from the south I-96 ROW border. MH-44A does not appear to be in an existing easement based on the alignment survey.

- From MH-35 (NOT 060002) to MH-34 (NOT 060001), the alignment is within a 15-foot-wide easement located in a private residence before changing back to the typical 20-foot width from MH-34 to MH-29 (NOT 085002).

- From MH-13 (NOT 102009) south to MH-8 (NOT 102004), the easement width is 20 feet. However, following the survey of the HRSDS alignment, the existing alignment in this section was found to be outside the existing easement with the alignment falling to the east of the current easement border by approximately 25 to 30 feet. AEW's discussions with OCWRC

concluded that this incorrect easement document will be corrected, and to move forward under the assumption that the easements for this section will be reconciled to match current sewer alignment.

- Additionally, the easement between MH-8 (NOT 102004) and MH-7 (NOT 102003) is currently undefined, with the exception of where the alignment crosses the railroad ROW.

For specific locations and additional information regarding the existing easements of the HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2, refer to the plan and profile drawings located in Appendix E.

3.3 SUBSURFACE CONDITIONS

NTH reviewed the available historical record information and performed initial subsurface explorations to provide our preliminary recommendations for future sewer rehabilitation. A summary of the historic subsurface soil and ground water conditions as well as the data obtained as part of the initial exploration is outlined in the following subsections.

3.3.1 Generalized Subsurface Conditions from Historical Data

Historical soil boring data provided in the 1968 "Soil Exploration" report by Michigan Drilling Company and in the 1970 "Soil Test Borings" reports by Testing Engineers and Consultants, Inc. indicated the following information on the general soil and groundwater conditions along the sewer's alignment.

For the approximately 1.5-mile segment of the sewer from the south end at manhole MH-EX (NOT 104003) to approximately manhole MH-21 (NOT 091008), subsurface soil conditions generally consist of a thin layer of surficial topsoil, sandy fill, or clayey fill. Below the surficial soils, native soils were encountered, consisting mostly of granular deposits. Most of the existing sewers within this segment appear to have been constructed through these granular deposits. The granular deposits were described as moist or wet medium to coarse sand and gravel, sand with pebbles, coarse sand, medium sand, and silty sand. The reported relative density of the native granular soils ranged from medium compact to compact. Groundwater was encountered at all soil borings drilled along this segment. The soil borings reported groundwater at completion of drilling observed at depths ranging from approximately 1 foot to 20 feet below the then ground surface (1968 – 1970). In all cases, the observed groundwater level was above or within the sewer pipe elevations. In some cases, heavy groundwater was reported in the soil boring logs.

For the remainder (northern segment) of the sewer located between manholes MH-21 (NOT 091008) and MH-45 (NOT 058002) near the north end of the sewer alignment, the historical soil borings along this reach indicated that the subsurface soil conditions generally consist of a relatively thin layer of topsoil or sand and gravel fill. Below the surficial soils, native soils consisting of mostly clayey deposits were reported to extend to the end of the soil borings, except for few soil borings where thicker strata of granular materials were encountered. The native clayey soils were described as moist sandy or silty blue or brown clay with sand and pebbles. The reported consistency of the clayey soils ranged from stiff to very stiff. Groundwater was encountered at six (6) of the ten (10) soil borings. The soil borings reported groundwater at completion of drilling being at depths ranging from approximately 1.5 feet to 14.5 feet below the then ground surface (1968 – 1970). In all cases, the observed groundwater was at

elevations above or within the 36-inch sewer pipe levels. Most of the groundwater appeared to be within thin granular layers except for the few borings where relatively thicker granular deposits were reported. Per the historical as-built drawings, the 36-inch sewer pipe appears to have been constructed within these wet granular deposits. Refer to the historical soil borings included in Appendix A for additional information.

3.3.2 Current Subsurface Conditions at Infiltration Locations

Following the recommendations included in our Memorandum "2019 Vs 2022 CCTV Comparison Summary at High Consequence Areas", dated June 29, 2023 (Appendix C), NTH performed subsurface exploration at various existing sewer infiltration locations as part of the initial exploration in July 2023. The purpose of this geotechnical exploration was to obtain additional information regarding soil and groundwater conditions along the sewer alignment, including identifying loose soil zones or voids around the sewer at historic infiltration (runners and gushers) locations in high consequence areas which would allow for developing ground stabilizing options prior to sewer rehabilitation. The exploration locations were selected based on review of the historical drawings, available soil data, and the existing CCTV data showing the condition of the sewer and historic infiltration locations.

Review of the historical soil information in the vicinity of the infiltration locations indicated that at some of these locations, the general soil profile consisted of mostly clayey materials. Such materials are not considered susceptible to soil migration with groundwater movement, as is the case with granular soils. As such, NTH selected a total of five (5) locations where the infiltrations were located near high consequence areas such as buildings, roadways or utilities, or where the subsoil profile consisted of mostly granular soils. The test borings were drilled in the zone directly above the sewer pipe to allow for more accurate identification of the voids/loose zones at the infiltration locations. At the location of the two (2) test borings drilled in the 10 Mile Road area, voids and loose soils were discovered, which led to implementing the surface grouting mentioned later in the section titled HRSDS Previous Inspections and Repairs. The data obtained during the NTH geotechnical exploration, along with our evaluations, recommendations, and analyses, are provided in the attached Geotechnical Exploration Report, dated July 13, 2023, in Appendix F.

3.4 ENVIRONMENTAL SITE ASSESSMENT

In order to identify sites of potential environmental concern (PEC), NTH performed a 60-foot-wide Preliminary Environmental Corridor Study along the project corridor which extends from north of the I-96 freeway between Lake State Railway (railroad easement) and Taft Road to Chattman Street north of 9 Mile Road. Based on our visual survey of the project corridor, the corridor traverses through lightly to heavily vegetated/wooded areas, low-lying marshy areas, railroad crossings and paved roadways. The sites adjacent to, or along the project corridor are occupied by railroads, and residential, commercial and/or industrial developments. The commercial developments include retail stores, car rental business, and auto repair shops. The industrial uses include warehouses and industrial/manufacturing facilities. Further, NTH obtained an environmental database search report to identify sites of PEC from Environmental Data Resources, Inc. (EDR), a private environmental information agency. Note that this study consisted of conducting a visual survey of the project corridor, reviewing an environmental database search report listing sites of PEC, and reviewing historical aerial photographs and topographic maps. Based on our study, we identified 14 sites of PEC along the project corridor, as listed in Table 1 below.

Table 1: HRSDS Rehabilitation Project – Potential Environmental Concern (PEC) Locations

Location No.	Site Location/Address	Current Occupant/User	PEC	Potential Manholes/Reaches Affected
1	44500 and 44700 Grand River Avenue	Fleet Automotive	Industrial uses with evidence of surface debris including 55-gallon drums, metal containers, tires, and auto parts. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-40 (NOT 059001) to MH-44 (NOT 058003)
2	44922 Grand River Avenue	Superior Materials	Site of known soil and/or groundwater contamination based on its listing in the regulatory agency database. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-41 (NOT 059002) to MH-44 (NOT 058003)
3	44300 Grand River Avenue	Power Vac of Michigan	Industrial uses and listing of the site in State's leaking underground storage tank (LUST) database. Refuse dumpsters with visual evidence of spillage and staining on the surrounding surfaces. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-37 (NOT 060005) to MH-39 (NOT 060007)
4	44170 Grand River Avenue	Harold's Frame Shop	Auto-repair shop with scattered surface debris comprising of tires, car parts, and chemical containers. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-37 (NOT 060005) and MH-38 (NOT 060006)
5	44109 Grand River Avenue	Novi Building Services	Site of known soil and/or groundwater contamination based on its listing in State's LUST database. Haphazard storage of construction equipment and materials observed. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-34 (NOT 060001) to MH-36 (NOT 060003)
6	43600 and 43800 Gen Mar Drive	CVS Health	Site of known soil and/or groundwater contamination based on its listing in the regulatory agency database. Site contains a railroad spur and scattered debris. Typically, heavy metals, polynuclear aromatic hydrocarbons (PNAs or PAHs) and polychlorinated biphenyls (PCBs), associated with preservatives used on railroad ties, brake oil, residues from train exhaust and slag/foundry sand in ballast material are of concern for railroads.	Reaches between manholes MH-28 (NOT 085001) to MH-32 (NOT 085005)
7	Novi Road and Railroad Crossing	Vacant parcel	Site of known soil and/or groundwater contamination based on its listing in the regulatory agency database.	Reaches between manholes MH-27 (NOT 090003) and MH-28 (NOT 085001)
8	25100 Novi Road	Gerber Collision & Glass and Enterprise	Site of known soil and/or groundwater contamination based on its listing in the regulatory agency database. The site is an auto-repair shop. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-24 (NOT 091011) to MH-26 (NOT 090001)
9	25460 Novi Road	Enamalum Corp/Rainbow Coatings Inc.	Industrial uses and site of known soil and/or groundwater contamination based on its listing in State's LUST database.	Reaches between manholes MH-27A (NOT 090004) and MH-28 (NOT 085001)
10	25425 Trans-X Drive	Temperform Corp	Industrial uses and site of known soil and/or groundwater contamination based on its listing in the regulatory agency database. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-25 (NOT 091012) to MH-27B (NOT 090002)
11	25000 Novi Road	Michigan CAT	Industrial uses and site of known soil and/or groundwater contamination based on its listing in the regulatory agency databases.	Reaches between manholes MH-23 (NOT 091010) and MH-24 (NOT 091011)
12	25975 Trans-X Drive	Guhring Inc.	Industrial uses and five 270-gallon totes labeled as lubricant oil were observed. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-19 (NOT 091006) to MH-21 (NOT 091008)
13	42780 W 10 Mile Road	Outdoor Accents Inc.	Former landfill and site of known soil and/or groundwater contamination based on its listing in the regulatory agency database.	Reaches between manholes MH-14 (NOT 091001) to MH-18 (NOT 091005)
14	42445 W 10 Mile Road	Durr Automotive	Industrial use and site of known soil and/or groundwater contamination based on its listing in the regulatory agency database. No information is available regarding hazardous material management and waste disposal practices implemented on the premises.	Reaches between manholes MH-7 (NOT 102003) to MH-13 (NOT 102009)

Details of the study along with descriptions of the PEC sites can be found in the attached Preliminary Environmental Corridor Study Report, dated July 13, 2023, in Appendix G.

The findings of the preliminary environmental study were utilized in determining if further environmental study to define the severity of contamination is necessary at selected access shaft/pit locations (where excavations for access are anticipated), and to establish an Environmental Construction Management Plan for construction of the project.

3.5 HRSDS HYDRAULICS AND OPERATION

In preparation for determining the specific rehabilitation methods to be utilized, NTH requested that ASI perform a hydraulic analysis of the existing pipes. This section presents the results of this hydraulic analysis including the existing capacities of the sewer reaches and the impact of reduced diameters due to potential rehabilitation.

As part of a long-term corrective action plan for Wayne County Public Works, ASI developed and calibrated a SWMM model of the RVSDS which was finalized in 2017. This model included the HRSDS as an upstream tributary branch. The model representation of the HRSDS was taken from the larger RVSDS model and updated to reflect current conditions including the addition of a storage retention facility completed in 2020 and the inclusion of the Novi Trunk Extension No. 1 - Contract 3 along 11 Mile Road which was not originally part of the RVSDS model development. Note that the tributary service area of the proposed rehabilitation work is 9,255.2 acres and is entirely within the City of Novi.

Flow from the City of Walled Lake was previously tributary to the upstream end of the HRSDS by overtopping a side weir at a diversion manhole at the intersection of Park Drive and West Road. A downstream gate on the trunk sewer tributary to the Walled Lake-Novi Wastewater Treatment Plant could also be closed and flows would eventually back up over the side weir and be entirely diverted to the HRSDS. OCWRC records indicated that in July 2012 this connection was bulkheaded and the diversion gate was removed. A field visit by ASI in September 2023 confirmed this. This analysis assumed the diversion will remain bulkheaded into the future.

3.5.1 Monitoring Data

The flows from the City of Novi portion of the HRSDS are monitored by Meter BG-1 (a.k.a. Meter 5730) at 8 Mile Road. This meter has a long-term record of which the last 5 years of monitoring reports were obtained and the dry weather averages and the peak wet weather flow rates were compared to the model predicted results. Table 2 presents this comparison.

3.5.2 Existing Sewer Capacity

The sewer geometry information for the rehabilitation reach was compiled and is presented as a profile on Figure 2 with the SWMM model predicted maximum 25-Year, 24-Hour Design Event hydraulic grade line (HGL). The rehabilitation reach was then divided into reaches of prevailing diameter and slope and the full pipe capacity was computed for each reach and is presented in Table 3.

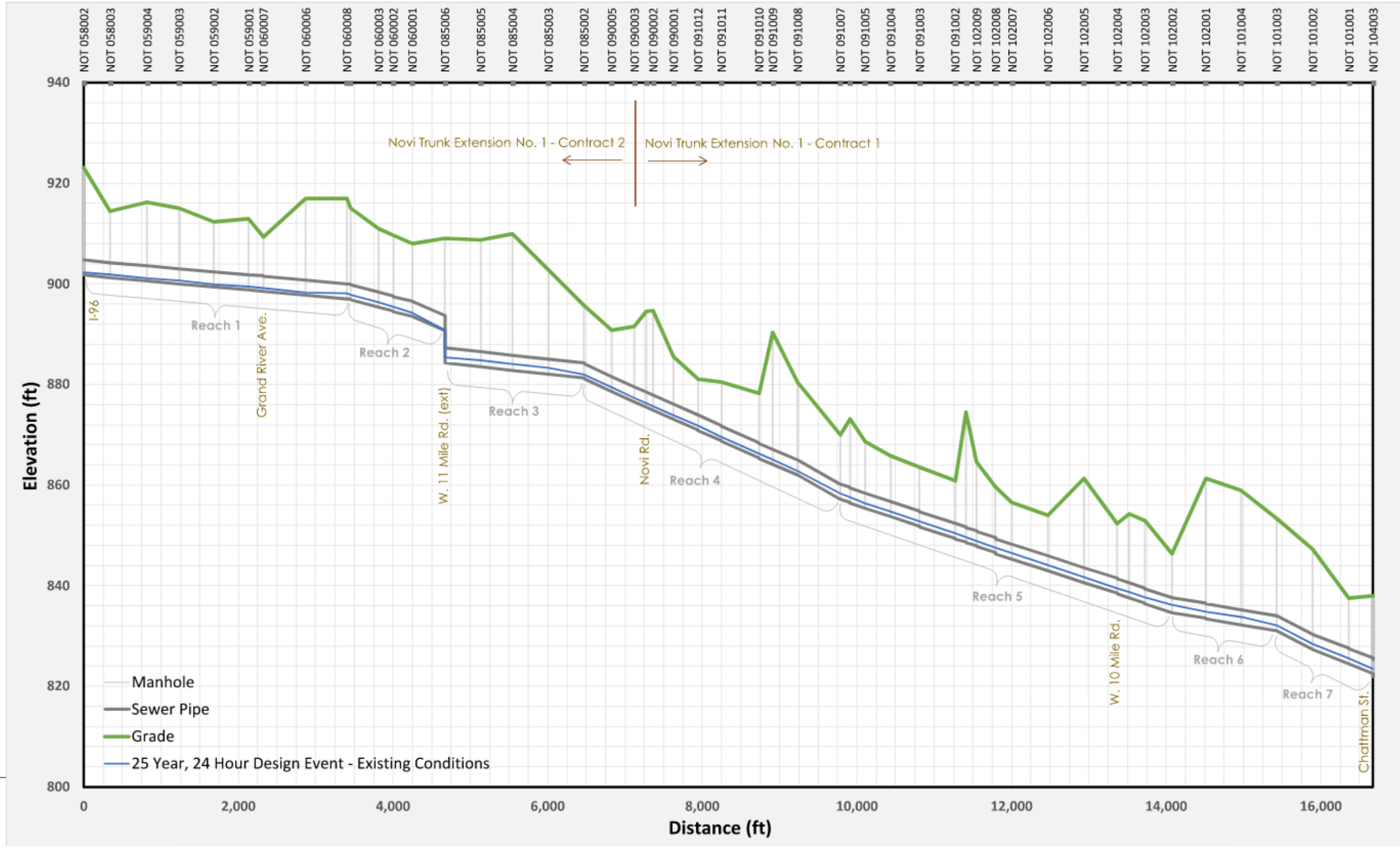
Table 2: Monitoring Data Summary for Meter BG-1

Year	City of Novi (Meter BG-1)		Downstream End of Rehabilitation Reach (Approx. 56% of Meter BG-1)	
	Springtime Average Dry Weather Flow Rate (cfs)	Peak Hour Wet Weather Flow Rate (cfs)	Springtime Average Dry Weather Flow Rate (cfs)	Peak Hour Wet Weather Flow Rate (cfs)
From RVSDS Monitoring Reports				
2018	7.3	15.1	4.1	8.4
2019	7.5	22.7	4.2	12.7
2020	7.3	22.5	4.1	12.6
2021	6.5	16.9	3.7	9.5
2022	7.4	21.9	4.2	12.3
From 25 Year, 24 Hour Design Event SWMM Model				
--	7.2	24.9	4.1	14.1

Table 3: HRSDS Sewer Capacity by Reach versus Predicted Flow Rate

Reach	Upstream GIS Facility ID	Downstream GIS Facility ID	Diameter (in)	U/S Invert (ft)	D/S Invert (ft)	Length (ft)	Prevailing Slope	Existing Conditions		
								Roughness Coefficient	Full Pipe Capacity (cfs)	25 Year, 24 Hour Design Event Peak Flow Rate (cfs)
Rehabilitation Reaches										
1	NOT 058002	NOT 060005	36	901.74	896.99	3,451.3	0.14%	0.014	23.0	7.0
2	NOT 060005	NOT 085006	36	896.89	890.77	1,218.5	0.50%	0.014	44.0	7.9
3	NOT 085006	NOT 085002	36	884.27	881.35	1,761.9	0.17%	0.014	25.3	8.7
4	NOT 085002	NOT 091007	36	881.16	857.25	3,223.0	0.74%	0.014	53.5	12.4
5	NOT 091007	NOT 102002	36	857.17	834.66	4,607.5	0.49%	0.014	43.4	14.3
6	NOT 102002	NOT 101003	36	834.66	831.05	991.2	0.36%	0.014	37.5	14.3
7	NOT 101003	NOT 104003	36	831.05	822.56	1,349.0	0.63%	0.014	49.3	14.3
Downstream Reaches										
--	NOT 104003	NOT 138012	42	821.86	813.62	4,344.0	0.19%	0.014	36.8	18.7
--	NOT 138012	NOT 136006	42	813.62	799.94	5,755.0	0.24%	0.014	41.2	25.3

Figure 2 – HRSDS Novi Trunk Extension No. 1, Contract Nos. 1 and 2: 25-Year, 24-Hour Design Event Maximum Hydraulic Grade Line Profile



3.6 THREATENED AND ENDANGERED SPECIES EVALUATION

Barr completed a desktop study of the threatened and endangered (T&E) species within the approximate project work limits, which included a review of aerial photographs, the Michigan Natural Features Inventory (MNFI) database, and the United States Fish and Wildlife Service (USFWS) Information for Planning and Consulting (IPaC) database. Following the desktop review, Barr identified six (6) federally listed species and nine (9) state listed species that have documented, field-verified occurrences within the proposed work area. The species include birds, reptiles, mammals, insects, and plants. Recommendations to avoid impacts on these species are included in later sections of this report. A full list of the species identified can be found in the attached Threatened and Endangered Species Evaluation Memorandum, dated August 10, 2023, in Appendix H.

3.7 WETLAND DELINEATION

Barr also completed a Wetland Delineation study for the project area. Wetland boundaries within a 60-foot-wide corridor along the alignment of the HRSDS were flagged during the period of July 10-13 and July 19, 2023. The wetland boundaries were flagged in the field with alpha numeric labeled pink flagging tape. Flagging was located using a GPS unit capable of sub-meter accuracy. Several regulated wetlands do exist along the project corridor. Impact of the existing wetlands and requirements for permits from governmental agencies are included in later sections of this report. A copy of the wetland boundary survey is enclosed with Barr's "Wetland Delineation and Opinion of EGLE Jurisdiction" Memorandum dated August 10, 2023, in Appendix I. The wetland boundaries within the studied sewer corridor are also indicated in the Plan and Profile Drawings included in Appendix E.

4.0 HRSDS PREVIOUS INSPECTIONS AND REPAIRS

As described earlier, NTH prepared a project memorandum describing the conditions of the HRSDS Novi Trunk Extension No. 1 Sewer between inspections in 2019 and 2022. One of the reaches involved in this comparison was between manholes MH-14 (NOT 091001) to MH-13 (NOT 102009) since it was discovered to have gushing and running infiltration and it crosses a major roadway at 10 Mile Road. During this investigation, it was discussed that in-sewer grouting operations had occurred in 2022, but NTH did not have access to the post-grouting CCTV files at that time. NTH was informed that in November 2022, in-sewer chemical grouting operations were performed by DVM Utilities, Inc. using remote packer techniques to seal the existing running/gushing infiltration locations from inside the sewer. This portion of the sewer was bypassed during chemical grouting operations. Review of the CCTV recording of the post grouting operation indicated that the running/gushing infiltrations within this reach were sealed. See the attached Memorandum "2022 Post Grouting CCTV at 10 Mile Road Crossing Between Manholes NOT 091001 and NOT 102009" dated July 13, 2023, in Appendix C for additional information.

Following the CCTV evaluation, NTH performed a geotechnical exploration to investigate the potential presence of voids/loose soils around the sewer where historic infiltration was observed at locations of high consequence, such as under roadways. Since the reach in question (between manholes MH-14 (NOT 091001) and MH-13 (NOT 102009)) included gushing and running infiltration, it was made a priority during our Geotechnical Investigation phase of the rehabilitation project. As a result, two (2) test borings (TB-1 and TB-2) were selected within 10 Mile Road to identify if there

was evidence of voids/loose zones where the historical gushing and running infiltrations were previously located. During our geotechnical investigation in June 2023, a zone of potential void/loose soil was discovered at TB-1 directly underneath 10 Mile Road.

Upon discussing the findings with OCWRC, NTH developed surface grouting plans for emergency grouting operations to fill the potential void/loose soils and stabilize the soil surrounding the sewer to prevent a potential sinkhole within the roadway. Given that the historic running/gushing infiltrations had previously been repaired, the relatively small 36-inch pipe diameter, and flow conditions, NTH determined that surface grouting would be the preferred method rather than in-sewer grouting. Following additional discussions with OCWRC, Pipeline Management was selected by OCWRC to coordinate the work and provide CCTV monitoring, with Spartan Specialty Services as their subcontractor to perform the surface grouting. Approximately 232 cubic feet of grout were pumped into 21 grout holes that were installed in the zone above the sewer within the 10 Mile crossing area. See Memorandum "Surface Grouting of Potential Voids - 10 Mile Road Crossing Between Manholes NOT 091001 and NOT 102009" dated September 11, 2023, included in Appendix C for additional surface grouting information.

5.0 LINER STUDY

As discussed in the condition assessment section, the CCTV footage revealed that most of the reaches in HRSDS Novi Trunk Extension No. 1 have structural defects resulting from MIC. Furthermore, these defects are observed over long continuous lengths within the reaches and indicate an incremental thinning of the sewer's pipe wall. Generally, structural degradation of the pipe proceeds from aggregate visible to aggregate projecting to aggregate missing and then to reinforcing visible, reinforcing projecting, and finally to reinforcing missing. Once the reinforcement is exposed and begins to corrode, pipe failure is imminent. As such, we studied various lining technologies available in the market to structurally rehabilitate the sewer and are described in the following sections.

Data collection and evaluation of the various technologies was based on a desktop study, product manufacturers' presentations at the OCWRC office and the NTH Northville office, and technical product data sheets obtained from the manufacturers' as well as product websites. After data collection, the products were evaluated based on their relative performance with respect to proven history of applications, constructability, and service life.

The liner technologies evaluated for the rehabilitation were grouped into five (5) types of systems: slip-lining, grout-in-place lining, tight-fit lining, cure-in-place pipe, and spray-on/coating applications. A total of 18 sewer lining products were evaluated as part of the BOD. Further, the liner evaluations narrowed the viable rehabilitation solutions down to 12 products that showed potential of performing well within the HRSDS environment and that were adaptable to the difficult construction constraints within the sewer. See Table 4 provided at the end of this section for additional information regarding rehabilitation technologies considered for this project.

5.1 SLIP-LINING

Slip-lining is one of the oldest forms of rehabilitation of an existing interceptor. The process consists of inserting a new, smaller-diameter liner pipe into an existing host pipe and filling the annular space between the host pipe and the liner pipe with grout. The liner pipe is pushed or pulled from an insertion point to its final location within the host pipe. Slip-lining is generally not designed as a composite system that structurally depends in part on the old host pipe, so high pressure water blasting preparation of the existing concrete lining is not required. Typically, the slip-lining method uses a liner that can support the surcharge (live and dead) loads, and non-structural grout between the host pipe and liner pipe to provide confinement. Our study considered the following slip-lining products:

- **Fiber Reinforced Polymer (FRP) Pipe:**
  - Hobas by Hobas Pipe USA
  - Flowtite by Thompson Pipe Group
  - Channeline by Channeline International
  - Stifpipe by QuakeWrap
  - Superlit by Superlit GRP
- **High Density Polyethylene (HDPE) Pipe:**
  - Threaded HDPE Jack Pipe – ThreadLiner by ISCO
  - Fusion Welded HDPE by ISCO
  - Spirolite HDPE by ISCO
- **Clay Jack Pipe:**
  - Logan Clay Pipe
- **Polyvinyl Chloride (PVC) Liners:**
  - Vylon PVC Slip-liner by Underground Solutions
  - Fusible PVC by Underground Solutions

Due to the 36-inch internal diameter of the HRSDS, slip-lining methods that could be performed from the existing 4-foot manholes without the construction of access shafts were prioritized, however some access shafts may be required regardless of the lining product in order to slip-line more efficiently. The size of the shaft required is based on the specific product, the length of the pipe sections to be placed, and the method selected to move the liner pipe from its insertion point to its final installation location. Methods for installation include jacking and pulling for this sized installation. Slip-liners can be installed as pipe sections which can range from 2 feet to 20 feet in length depending on the manufacturer or installed as continuous (no joints) liners in the case of fusible HDPE and PVC. The slip-liner products evaluated here form fully structural liners; as such, the annular space between the slip liner and host pipe must be filled with a non-shrink grout to provide confinement. The grout can be relatively low strength, such as foam grout.

Fiber Reinforced Polymer Pipe - Five (5) FRP slip-liners were considered as part of the BOD: Thompson Flowtite, Hobas, QuakeWrap StifPipe, Superlit, and Channeline International (Figures 3-7). However, Channeline dropped from pre-qualification as they decided not to participate in the initial information gathering presentation. Channeline stated that this project is not suited to their rehabilitation technology and are concerned about the quality control and safety during liner installation. The FRP liners possess relatively thin wall sections which allow for the construction of many different internal diameter (ID) sizes as required by the hydraulic analysis, with some

manufacturers providing flush joints that provide a relatively homogenous outside diameter (OD) measurement. The FRP liner products are also flexible and able to navigate minor deflections in the alignment and minor sags/offsets. Due to similar manufacturing methods, the FRP liners can also be cut to almost any length necessary for the installation conditions. These lengths range from 20 feet for the long segment installations, to 2-3 feet for the manhole-to-manhole installations, except for Hobas pipe (which comes in minimum 5-foot sections). For the long segment installations, the FRP liners are able to line through multiple manholes at once for lengths ranging from 1,500 to 5,000 feet if an access structure is constructed. Depending on the installation type, the Hobas, Thompson Pipe Group, QuakeWrap, and Superlit claim that their products can be installed in live flow conditions; however, construction of bulkheads and grouting the annular space will require some form of temporary storage or bypass pumping, either externally or internally using a plug and flow-through pipe. Prior to the installation of the FRP slip-liners, minimal surface preparation of the host pipe is required, with typical requirements including jetting to remove settled debris and obstructions that could interfere with lining insertion.

There are some limitations to the FRP slip-liners as well, including the need to excavate for the reinstatement of lateral blind taps. Other considerations include repairing the FRP liners will require fiberglass lamination, humidity control, and require bypass pumping. Furthermore, product manufacturing locations should also be considered. QuakeWrap Stifpipe can be manufactured as close as possible to the jobsite, Hobas is manufactured in Texas, and Thompson and Superlit liners are both manufactured in Turkey. The cost and lead times for shipping will play a role in the overall cost consideration of the project.

Figure 3: Thompson Flowtite Pipe Installation ***(Photo Courtesy of Thompson Pipe Group Presentation)***

Figure 4: Hobas Pipe Installation (*Photo Courtesy of Hobas Pipe USA Website)*

Figure 5: QuakeWrap StifPipe *(Photo Courtesy of QuakeWrap Presentation)*

Figure 6: Superlit Pipe *(Photo Courtesy of Superlit GRP Presentation)*

Figure 7: Channeline Pipe *(Photo Courtesy of Channeline International Website)*

High Density Polyethylene Pipe - We also considered three types of HDPE slip-liners for the HRSDS rehabilitation: fusion-welded HDPE, threaded HDPE segmental jack pipe, and Spirolite HDPE slip-liner (Figures 8-10). Due to the installation method of pulling longer sections of pipe into place that would require larger insertion shafts/pits, the fusion-welded HDPE liner method would be recommended only for the long lining sections with liner distances able to be pulled the entire lengths of the straight sections which range in length from 546 ft to 3,388 ft, while the 2-to-3-foot-long threaded HDPE pipe sections would be ideal in the manhole-to-manhole designated installations. The flexibility of the fusion welded HDPE pipe also enables the liner to navigate minor alignment changes and sags/offsets with relative ease. The fusion-welded HDPE slip-liner can also be installed in two methods: the traditional pull-in-place method or the compression-fit method, which takes an HDPE pipe with an OD slightly larger than the host pipe and compresses it during installation. The compression-fit pipe is then released once it reaches the termination point and expands into a tight-fitting, grout-less liner. The compression-fit requires the same launching and receiving pits as the traditional pull-in-place HDPE liner. The Spirolite HDPE slip-liner is similar to the ThreadLiner product, but with installation requirements similar to the FRP products. The ThreadLiner and the Spirolite products can also be installed in live flow conditions depending on the pulling configuration but will likely require some level of flow bypass or storage for annulus grouting operations and will also require excavation to reinstate lateral blind tap connections.

Figure 8: Fusion-Welded HDPE Pipe (*Photo Courtesy of Trenchless Technology Magazine Website)*

Figure 9: ThreadLiner HDPE Pipe (*Photo Courtesy of ISCO Website)*

Figure 10: Spirolite HDPE Pipe *(Photo Courtesy of ISCO Website)*

Logan Clay Pipe - Another slip-lining product that was evaluated for the HRSDS rehabilitation project was Logan Clay Pipe (Figure 11). The jacked-in-place clay slip-liner is fabricated with stainless steel collars to allow for greater axial load during pushing or pulling slip-lining installations. Due to the weight per foot and the more rigid joints of this product which do not allow for significant deflection, manhole-to-manhole reaches would be the only likely installation method for this liner. A minimal footprint is required for installation of the clay jack pipe slip-liner, with a winch on the upstream end of the reach to pull the liner into place, plus a way to lower the liner sections into the sewer at the downstream end being the only equipment necessary onsite, unless a shaft is constructed, and jacking equipment is used. While Logan Clay Pipe has many potential benefits, they currently only manufacture a maximum diameter of 24 inches for their jack pipe product.

Figure 11: Logan Clay Pipe Installation ***(Photo Courtesy of Logan Clay Pipe Presentation)***

Polyvinyl Chloride Liners: Underground Solutions presented two PVC slip-lining products: Fusible PVC and Vylon PVC slip-liner (Figures 12 and 13). The fusible PVC product is very similar to the fusion-welded HDPE product discussed earlier in this section. The Vylon PVC slip-liner is installed in a similar manner to FRP and Spirolite HDPE products.

Figure 12: Fusible PVC Pipe (*Photo Courtesy of Underground Solutions Presentation)*

Figure 13: Vylon PVC Slip-Liner Installation ***(Photo Courtesy of Underground Solutions Presentation)***

5.2 TIGHT-FIT LINING

Two types of Spiral-Wound (SPR) tight-fit liners from Sekisui were also considered. These products include Sekisui SPR-EX and SPR-TF/RO (Figures 14 and 15). Both of these liners are constructed of PVC material that is applied via a winding machine through existing manholes to create tight-fitting liners against the host pipe with no annulus grouting required. Sekisui stated during their presentation that these products can be installed in live flow conditions, given the flow is approximately 1/3rd of the cross-sectional area, and the flow rate is approximately 2-3 cubic feet per second (cfs).

Sekisui SPR-EX - The SPR-EX product consists of placing the winding machine at an existing manhole where it creates a smaller diameter liner until it reaches the receiving manhole. At the receiving end, the liner is then torsionally restrained, and the secondary locking mechanism is removed, allowing the liner to expand by continuing to wind it until it is tight-fitting with the host pipe. A disadvantage of the SPR-EX product is that only one spool can be installed at time and spools cannot be spliced together. This results in a maximum installation length of approximately 250 feet; therefore, this product is only recommended for short reaches of the sewer.

Sekisui SPR-TF/RO - The SPR-TF/RO product uses a winding machine that travels along the length of the reach to be lined while placing a tight-fit liner. The SPR-TF/RO product allows for spools to be spliced together, so the maximum installation length is only limited by the hydraulic hoses and pressure required to power the winding machine.

Figure 14: Sekisui SPR-EX Liner Installation (*Photo Courtesy of Sekisui Website)*

Figure 15: Sekisui SPR-TF/RO Liner Installation *(Photo Courtesy of Sekisui Presentation)*

5.3 GROUT-IN-PLACE LINING

Grout-in-place lining is a trenchless method of sewer rehabilitation that involves the use of an internal liner material and grouting of the annular space to achieve structural or non-structural rehabilitation (only corrosion protection) of a sewer. For smaller diameter pipes, the liner material is typically fed from a spool into the existing host pipe through a shaft or existing access manhole. The liner material is then wound within the host pipe and typically internally braced to maintain shape during grouting. The annular space between the liner and host pipe is typically grouted using structural grout depending on the liner system and structural requirements of the specific application. The internal liner acts as the inner form and the corrosion protection for the final grout-in-place liner system.

Typical GIPL liner materials are high-density polyethylene or polyvinyl chloride. The HDPE/PVC liner may or may not include steel reinforcement. It is common for the grout in the annular space to structurally join the HDPE/PVC with the host pipe. The bond to the host pipe may be achieved by a mechanical bond to a properly prepared host pipe surface, or through the pre-installation of anchors prior to installation of the internal liner. Our liner study considered one GIPL product: Sekisui SPR PVC Liner (Figure 16).

Collecting ragging and debris on the temporary internal bracing and behind liner sections waiting to be grouted are concerns that can slow liner installation productivity and affect the final performance of a GIPL system if full bypass pumping is not provided during liner installation. Ragging and debris getting behind liner sections is a major concern for systems that require composite action between the liner, structural grout, and host pipe to achieve a structurally sound liner. Full bypass pumping will be required during the SPR installation process in order to efficiently install the liner and keep the annular space clean for grouting. Additionally, GIPL systems typically require spacers between the liner and host pipe to maintain uniform grout thickness around the liner.

Figure 16: Sekisui SPR GIPL Liner Installation *(Photo Courtesy of Sekisui Website)*

5.4 CURED-IN-PLACE AND FOLD-AND-FORM LINING

Cured-In-Place Pipe lining is a common trenchless method for rehabilitating sewers by the insertion of a resin impregnated flexible lining, typically consisting of polyester felt or fiberglass depending on the manufacturer, through existing manhole structures that is cured-in-place against the existing pipe to form a new pipe lining. The CIPP is saturated with a thermosetting resin and inserted into the existing pipe (Figure 17). Curing is accomplished by circulating hot water, heated air, or ambient cure, to harden the resin into a hard impermeable pipe. When cured, the hardened CIPP will be a tight fitting watertight structural pipe within a pipe. The CIPP must be continuous from manhole to manhole with no circumferential joints or seams.

Fold-and-Form lining works in a similar manner, where an HDPE or PVC pipe is extruded, heated, folded, and coiled for delivery to project sites. The liner is then re-heated and inserted into the host pipe where it is introduced to steam and air pressure to expand the liner tightly against the host pipe. Both CIPP and Fold-and-Form lining methods require 100% bypass pumping during installation and curing/expanding.

For both CIPP and Form-and-Fold liners, a large footprint at each access manhole is required for the equipment. This includes boiler trucks, equipment to invert/lower the liners into the host pipe, and delivery equipment including refrigerated tractor trailer (commonly referred to as "reefer" trucks) for CIPP and steam cabinets usually on flatbed trailers for Fold-and-Form liners. Additionally, for traditional felt or fiberglass CIPP liners, sags in the host pipe can be difficult to cure and oftentimes result in areas that are soft and have to be re-cured or repaired prior to the reintroduction of flow. Reinstatement of laterals can generally be performed from within the lined pipe.

The cured-in-place pipe and fold-and-form lining solutions considered for this project included:

- **Polyester Felt or Fiberglass CIPP by various liner manufacturers**
- **Fold and Form PVC**
    - NovaForm PVC liner by IPEX
    - Thermoform PVC liner by Thermoform

- **RigidSeal Pipelining System by Rigidseal**
- **Manufactured-in-Place Composite Pipe (MICP) by SippTech**

Polyester Felt or Fiberglass CIPP - The flexible liners used for CIPP, commonly referred to as tubes, are constructed of either polyester felt or fiberglass. Recent development of technologies allows for tubes that are reinforced with various high tensile fibers capable of increasing the overall strength of the finished CIPP. The benefit of using fiberglass tubes is the higher strength and flexible modulus provided by the fibers, and the ability to reduce the wall thickness/weight of the finished CIPP liner. The lower weight also helps with material handling and increases the length of liner that can be transported to the jobsite. During SAK's CIPP presentation, SAK provided design wall thicknesses ranging from 15 mm to 24 mm for a felt tube, and 7.5 mm to 10mm for a fiberglass tube. The downside of using fiberglass instead of felt is the added cost of materials. Additionally, recent environmental concerns have arisen in regard to the styrene used in CIPP resins. Styrene releases a strong scent during the curing process of CIPP; however, the NASSCO released statements claiming that the styrene resins used in CIPP products are safe to use given the proper health and safety procedures are followed during installation and that notification is provided to nearby homeowners who may be affected. As an alternative, styrene-free products have since been developed to alleviate the concerns around styrene, however these products add costs to the CIPP manufacturing process.

Figure 17: CIPP Felt Liner Inversion during Elizabeth Lake Road Sinkhole Sewer Rehabilitation

NovaForm - NovaForm is a styrene-free expand-in-place PVC liner which is a type of Fold-and-Form lining (Figure 18). Currently, for sewers in the diameter range of the HRSDS, only 30-inch NovaForm PVC liners are available and can be "overexpanded" to fit a 36-inch diameter host pipe. Based on the observed section loss in the host pipe, one of the design requirements is that the lining system used is a fully structural liner. The thinning of the 30-inch diameter PVC wall thickness to fit the 36-inch diameter presents a concern to the structural capacity of this lining system. An additional concern is the fact that NovaForm has only been installed of lengths up to 400 feet to date, and several reaches within the HRSDS alignment have lengths exceeding 400 feet between manholes.

Figure 18: NovaForm PVC Liner *(Photo Courtesy of Trenchless Technologies Website)*

Thermoform – Thermoform is another fold-and-form PVC liner. During preliminary discussions, Thermoform stated that the depth of cover for this project ranges from 11 feet to 30 feet which will pose issues for their product. Assuming a fully deteriorated host pipe, site hydrostatic head, etc., their heaviest 36-inch liner will only carry a structural rating of approximately 10 feet to 12 feet depth.

RigidSeal - A new type of CIPP lining system is the RigidSeal product that uses a thermoplastic liner coated in a proprietary structural expanding polyurethane grout. The liner is "wet out" with grout at the entrance of the access shaft or manhole and is pulled into place similar to other CIPP products (Figure 19). Once the liner reaches the end of the lining segment, both ends are sealed and pressurized air is added to expand the liner into shape while the polyurethane grout sets up and creates a bond with the existing host pipe. The use of structural polyurethane grout also allows for the penetration through any defects in the host pipe to seal leaks or fill small voids during installation, which reduces the surface preparation required prior to installation. A concern with this experimental product is that there are no industry standards for design or compressive strength testing, combined with the fact that the largest installed diameter to date is 18 inches.

Figure 19: RigidSeal Pipeline Installation *(Photo Courtesy of RigidSeal Presentation)*

SippTech - SippTech is a manufactured-in-place composite pipe (MICP) rehabilitation solution (Figure 20). They currently only provide rehabilitation solutions for 48-inch diameter pipes or larger. The robotic applicator would need 100% bypass and a larger access structure than the existing manholes. No annulus space is produced in this rehabilitation method, so no grouting would be required, and the composite liner material is corrosion and abrasion resistant. Due to the size limitations, this technology doesn't meet the finished diameter requirement of this project.

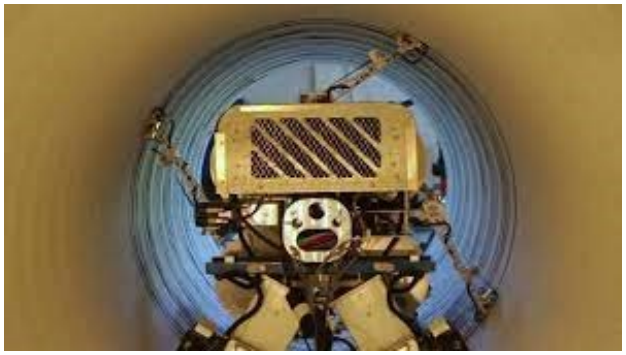


Figure 20: SippTech MICP Liner Installation *(Photo Courtesy of SippTech Website)*

Based on the project requirements, we do not recommend moving forward with NovaForm, Thermoform, RigidSeal, or SippTech lining systems. We recommend the use of traditional polyester felt or fiberglass CIPP liners for "manhole-to-manhole" installations.

5.5 SPRAY-ON COATING/LINING

Many spray-on/coating liner systems consist of either a cementitious based material, an epoxy-based material, fiber reinforced polymer, polyurethane, or a composite of a cementitious material with an epoxy topcoat. Spray-on/coating liners are typically used as a repair type rehabilitation where the liner is used to restore the existing concrete surface and provide corrosion protection (Figure 21). Spray-applied linings can generally be divided into two categories: Structural and non-structural; both typically provide some level of corrosion protection. For the spray-on/coating liner systems that provide structural improvement, the level of structural improvement depends on the specific loading, liner thickness, and host pipe conditions.

Figure 21: Spray-On Liner/Coating Installation *(Photo Courtesy of Municipal Sewer & Water Magazine Website)*

The performance of the spray-on/coating liner systems are all highly dependent on the condition of the substrate to which they are applied. The adhesion of a spray-on/coating lining to the substrate is considered a mechanical bond rather than a chemical bond, and the substrate should be prepared following International Concrete Repair Institute (ICRI) Requirements. This includes surface roughness, cleanliness, and moisture requirements for a proper bond for longevity. Most spray-on/coating liners are tolerant of moisture in the concrete; however, none of the spray-on/coating liner systems tolerate active infiltration. Additionally, performance of spray-on/coating linings is also affected by the cure time prior to the introduction of flow. Cure time can be affected by the air and substrate temperature at the time of application.

While spray-on coatings are considered a good solution for replacing lost section and certain types of coatings can be somewhat effective at inhibiting corrosion, a major disadvantage to the spray-on coatings option is that it will be susceptible to reflective cracking from existing cracks (if any) in the host pipe and will not protect the liner from development of future leaks. This issue can be mitigated by use of steel/mesh reinforcing prior to applying the lining material. Since leaks have historically been the cause of lost ground supporting the pipe and ultimately have led to major failures in similar sewer systems, spray-on coating is considered a 20-year fix and will require more frequent inspection and future repair than the lining systems discussed in the previous sections.

In general, application of the spray-on/coating systems can be achieved through existing manholes and other structures. Due to the HRSDS's internal diameter, the spray on coating would be very difficult to perform via manned-entry and would most likely be required to be performed robotically. Taking into consideration the surface preparation requirements and application challenges as well as the relatively shorter life span of the product, we do not recommend any spray lining/coating lining solutions. Due to the small diameter of the HRSDS, quality assurance and quality control could not be adequately tracked/performed and the humidity requirements for many spray-on lining products would be extremely difficult to achieve. Additionally, the spray-on lining/coating options have to be performed from manhole-to-manhole, and the disruption caused by long time periods of bypass pumping is also a factor in our decision not to recommend any spray-on lining/coating option for the HRSDS Rehabilitation Project.

Table 4: HRSDS Rehabilitation Project - Liner Products Comparison Summary

Product No.	Product	Description of Rehab Method	Typical Access Requirements	Typical Pipe Preparation Requirements	Bypass Pumping Requirements	Method Pros	Method Cons	Other Considerations	Estimated Liner Cost/Foot*	Presented by Manufacturer (Date)	Recommendation
	SLIP-LINING PRODUCTS										
1	HDPE - Fusion Welded (ISCO)	Fusion-welded continuous HDPE slipliner. Can be installed as standard slipliner with annulus grouting or Compression Fit that expands into tight-fitting groutless liner.	Larger diameter launching and receiving pits required. Rectangular shape preferred. Possible to perform with trench box instead of regular shaft.	Jetting to remove settled debris and obstructions that could interfere with lining.	Yes, full bypass most likely required	- Pipe is flexible and can navigate radius of 25x the OD. - Alternative installation method of Compression Fit is tight-fitting and would not required annulus grouting. Similar installation to regular continuous slipling. Provides Larger ID. - Able to pull long reaches at a time and navigate bends (1,500 - 2,000 feet preferred distance) - Can also fuse sections of 150-200 feet and install in a fuse-pull-fuse-pull situation. - Pulling takes less than a day once pipe is fused together - Jointless rehab solution once pipe is in place.	- Fusion has to occur topside in most situations. Possible to due in the shaft but not efficient. - Reinstating tap connections requires excavation. -Compression fit not feasible to pull thru large bends (22 degrees and larger)	- It takes approx. 1 hr 15 min to 1 hr 30 min to fuse one 30" diameter joint. - The fusing machine is approx. 10' x 6' - Maximum pull length used in previous projects was 7,000 ft for 48" diameter pipe using a directional drill rig as a pulling device. -32" Diameter DR 26 has been used in previous 36" host pipe in previous projects (ID of 29.39").	28"-30": Approx. $130/LF	Yes, at WRC (8/16/2023)	Recommended for consideration in the design phase
2	FRP: Hobas	FRP Slipliner. Flush Bell and spigot joint	Not able to install from existing manholes, larger diameter access pits would allow for longer pipe sections.	Jetting to remove settled debris and obstructions that could interfere with lining. Major infiltrations to be grouted.	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	- Can push distances of 2,000 to 5,600 feet. - May not need bypass pumping during installation. - May be able to line multiple reaches at once. - Can more easily handle sags as opposed to CIPP. - Less surface prep than CIPP or spray-on.	- Annulus grouting will most likely require bypass pumping. - Excessive number of Joints for small sections - Cannot slipline from existing manholes since manufacturing procedure allows for minimum pipe length of 5 feet.	- Manufacturer still prefers MH to MH installations where possible. - Fiberglass lamination for any defect repairs. Bypass pumping required for lamination. - Annulus grouting required.	28": $202 / LF (minimum 5' pipe lengths) 30": $231 / LF (minimum 5' pipe lengths)	Yes, at WRC (8/9/2023)	Recommended for consideration in the design phase
3	FRP: QuakeWrap	FRP Slipliner. Elastomeric or FRP couplings. Tentatively discussing 6' long sections Pulled and Pushed into place.	Larger Diameter access shafts preferred. Approx. 15 ft diameter speculated.	Jetting to remove settled debris and obstructions that could interfere with lining. Sags or offsets need further review. Gushing infiltration to be grouted.	Potential to perform installation without bypass pumping, but grouting operations will need internal flow-through bypass pumping. Some areas such as the drop structure at MH 33.	- 30 certified installers in North America. - Able to produce any size diameter. - Possible to install 1,000 to 1,500 ft at a time or across multiple manholes. - Ability to manufacture as close as possible to the jobsite. - Design will utilize internal and external protective coatings. - Lighter weight compared to other pipes. Highest weight to strength ratio on the market for FRP slipliners, also high axial strength for installation.	- Reinstating tap connections will most likely require excavation. - Excessive number of joints required for smaller pipe lengths.	- Joints can handle approx. 5-degrees of deflection. Possibly more if elastomeric couplings are used in place of FRP couplings. - Elastomeric couplings are faster install but heavier and more expensive, while FRP couplings take longer to install. - Preliminary estimates include using a 30"-32" OD liner (thickness of 0.5"-0.6"). - Lead time: 3 month setup and 8 month production time. - Centralizers will be used to keep the liner centered within the host pipe. - Multiple lifts of annulus grouting expected. - Will entertain material warranty of 10 years. Labor warranty dependent on partner. - Fiberglass lamination for any defect repairs. Bypass pumping required for lamination. - Annulus grouting required.	28": $400/LF (8' pipe lengths) 28": $420/LF (2' pipe lengths) 30": $420/LF (8' pipe lengths) 30": $440/LF (2' pipe lengths) Pricing includeds FRP couplings. For mechanical couplings, add $25/LF for 8' pipe lengths and $100/LF for 2' pipe lengths.	Yes, at NTH (8/23/2023)	Recommended for consideration in the design phase
4	FRP: Thompson Flowtite	FRP Slipliner. Flush joint (sleeve) system.	Able to install from existing manholes, larger diameter access pits would allow for longer pipe sections.	Jetting to remove settled debris and obstructions that could interfere with lining. Major infiltrations to be grouted	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	- 24, 28, and 30 inch ID sizes are readily available, but custom sizes can be made as well. - 28" ID pipe should be able to be installed from 4' MH.	- Reinstating tap connections requires excavation - Manufactured in Turkey, US Plant shutdown - Excessive number of joints for small sections	- Pushing distance capacity of approx. 2,660 ft. - Able to push upstream or downstream, but upstream preferred. - 2-degree deflection allowable. - Fiberglass lamination for any defect repairs. Bypass pumping required for lamination. - Annulus grouting required.	28": $120/LF (9' pipe lengths) 28": $180/LF (2.5' pipe lengths) 30": $128/LF (9' pipe lengths) 30": $195/LF (2.5' pipe lengths)	Yes, at NTH (8/8/2023)	Recommended for consideration in the design phase
5	GRP: Channeline	GRP Slipliner. Pulled out due to installation and field QA/QC concerns.								No	Not recommended.
6	GRP: Superlit	GRP Slipliner. Flush push-on coupling system.	Manufacturer suggests access structures at each manhole (approx. 6 ft x 16ft for 10 ft pipe sections)	Jetting to remove settled debris and obstructions that could interfere with lining. Chemical grout gushers to assist with annulus space grouting.	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	-Able to fabricate bends if necessary. - Manufacturer saddle connnections in-house. - Follow ASTM and other US/International standards. - Able to install 100-200m (328-656 ft) for slip-lining installations, and 400-500m (1312-1640 ft) for jacking installations. - Can install saddle connections during manufacturing, or can be glued on in the field.	- Manufactured in Turkey - can ship approx. 90 LF of 30-inch pipe per container. - Not currently approved for shipping/installation in U.S. market (in progress). - Push-on coupling cannot be pulled into place.	- Design life is 50 years. - 2 year warranty. - Plastic collars with spacers/rollers used to centralize liner. - Fiberglass lamination for any defect repairs. Bypass pumping required for lamination. - Annulus grouting required. - Trying to keep prices low in order to break into North American market.	$65.50 / LF for 2' long pipe section with coupling. $33.90 / LF for 10' long pipe section with one coupling. $26 / LF for fiberglass reinforced sewer bore pipe. $79 per coupling. All for 28" pipe.	Yes, Virtual (9/12/2023)	Recommended for consideration in the design phase
7	Logan Clay Pipe	Clay Pipe Slipliner. Fabricated with steel collars for pushing/pulling into place.	Utilize existing manholes, but will likely require modification by removing the cone section. Pilot Tube Guided Boring method of installation requires 8 ft diameter shaft.	Jetting to remove settled debris and obstructions that could interfere with lining. Chemical grout gushers to assist with annulus space grouting.	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	- High compressive strength of approx. 18,000psi. - Minimal footprint would likely include a pnuematic pipe bursting cable (large winch) at the upstream end and pipe sections with a way to lower them into the sewer at the downstream end and can be pulled in place. - Able to line multiple reaches if straight, depending on pulling/pushing method.	- Currently only make a maximum of 24 inch ID. Possible to make 27 inch ID work, but would not be standard Jacking Pipe configuration. - Reinstating tap connections requires excavation. - Joints do not have much deflection capacity. Approx. 3/8-inch per foot. - Clay pipe is heavy in terms of lbs per foot. May not be best option for lining long segments at a time due to force required to move the pipe sections.	- Able to install centralizers prior to installation to keep liner centered in host pipe. - Ceramic epoxy used to perform spot repairs if necessary. - Grout ports can be manufactured into the liner sections. May not be applicable due to the small diameter of this liner. - Standard pipe lengths of 1 -2 meters, but can make any length.		Yes, Virtual (8/25/2023)	Not recommended.
8	Threaded HDPE Jack Pipe - ThreadLiner	Threaded HDPE pipe sections can be connected by hand within existing manholes in 2' to 3' sections and jacked into place.	Utilize existing manholes	Jetting to remove settled debris and obstructions that could interfere with lining. Sealing of major infiltrations.	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	- 2' to 3' sections can be installed within existing manholes. - Manufactured in the United States - Lightweight material, so specialty jacking equipment may not be necessary. - Good for MH to MH applications.	- Threaded connections may be difficult to perform within manhole. - Annulus grouting will require bypass pumping. - Liner sections will need to be blocked during installation to prevent floating. - Excavation required to reinstate tap connections. - Difficult to navigate bends. Not ideal for long reach applications.		2' pipe lengths: $242.50/LF	Yes, at WRC (8/16/2023)	Recommended for consideration in the design phase
9	Spirolite HDPE - ISCO	HDPE slip-liner with bell and spigot joints.	Larger diameter access pits requried.	Jetting to remove settled debris and obstructions that could interfere with lining. Grout gushers.	Potential to perform installation without bypass pumping, but grouting operations will likely need bypass pumping	- Can be manufactured from 18" to 132" ID. - Custom joint lengths. - 100 year minimum design stress life cycle. - Same benefits of HDPE 4710 Pressure Pipe Resins. - Unique gasket design provides better seal than traditional o-rings.	- Reinstated tap connections requires excavation. - Annulus grouting will require bypass pumping.	- Can be installed as traditional bell and spigot or automated welding option for increased pressure ratings or added protection due to hazardous applications.		Yes, at WRC (8/16/2023)	Recommended for consideration in the design phase
10	PVC Slipliner - Vylon/Underground Solutions	PVC slip-liner. Usually installed in access pits of approx. 25ft x 10ft or similar. Possible to install in manholes, but not preferred.	Larger diameter launching and receiving pits required for efficient slip-lining.	Jetting to remove settled debris and obstructions that could interfere with lining. Grout gushers.	No bypass required for installation. Possibly flow-through for grouting.	- Manufactured in Bowling Green, Ohio. - Maximum push distance from case study is 5,300 ft, but 1,000-1,500 ft is typical. - Flush bell and spigot joint that has "locking" mechanism once gasket is compressed. - Simple installation. - Possible to install from MHs, but not standard or preferred. - Cheaper/lighter than GRP slip-liners	- Joints cannot navigate angle points at manholes. - Have to excavate to reinstate taps. - Need to have access at approx. every other manhole for grouting (can grout approx. 500 ft at a time). - Have to surcharge liner for grouting, blocking will damage the liner.	- Standard lengths of 16 ft but can make down to 2 ft sections. - If working from MHs, will need to remove cone section. - Inserta-Tee manufactures Vylon-specific tap connections. - Typical installation rate of 1 pipe every 3-4 minutes.	16' sections: 30" = $157 / LF; 27" = $124 / LF 10' sections: 30" = $185 / LF; 27" = $146 / LF 8' sections: 30" = $215 / LF; 27" = $169 / LF 6' sections: 30" = $245 / LF; 27" = $195 / LF 2' sections: 30" = $350 / LF; 27" = $278 / LF Unit pricing includes shipping.	Yes, at WRC (9/7/2023)	Recommended for consideration in the design phase
11	Fusible PVC - Underground Solutions	Fusible PVC slip-liner. Heat and pressure are used to fuse pipe sections togther.	Generally need long, sloped access pits (minimum of 100 ft long) for installation.	Jetting to remove settled debris and obstructions that could interfere with lining. Run a steel "can" through prior to installation to true the host pipe. Grout gushers.	Full bypass required.	- Able to pull long distances and through manholes. - Every joint is data-logged following fusing. - Thinner pipe wall than fusible HDPE. - No rest/shrinkage time following installation. - Able to handle gouge depths up to 10% of pipe wall before de-rating. - NSF 14 certified - Minimal profile increase at joints.	- Minimum pit length is 100 ft for a depth of 10 ft. - Less flexible than fusible HDPE. - Have to excavate to reinstate taps.	- C900 PVC pipe. - Able to use standard waterworks fittings. - Pipes come in 45 ft lengths.	30" DR 25: $255 / LF 30" DR 21: $300 / LF	Yes, at WRC (9/7/2023)	Recommended for consideration in the design phase
	TIGHT-FIT PRODUCTS										
12	Spiral Wound (SPR EX & SPR TF/RO) - Sekisui/SAK	**SPR TF/RO:** Winding machine travels along the length of the reach to be lined while placing a tight-fit liner. **SPR EX:** Winding machine placed at launching manhole creates a smaller diameter liner until it reaches the receiving manhole. The receiving end is then torsionally restrained and the secondary locking mechanism is removed, allowing the liner to expand by continuing to wind it until it is tight-fitting with the host pipe.	Utilize existing manholes	Jetting to remove settled debris and obstructions that could interfere with lining. Chemical grout gushers.	Can be installed in live flow if flow is 20-30% of cross sectional area and low velocity (2-3 cfs). Can release flow at end of work day.	**Both:** - Can be installed in existing manholes with no modification. - No grouting required. - Possible to be installed in live flow. - Already designed for 6"-42" diameter pipes. - Fully structural. - Able to navigate offsets, sags, and bends less than 15 degrees at manholes. - Minimal footprint (as little as 10' x 10'). Just need spool and generator topside, most of the work is within the pipe. **SPR EX:** - Winding machine stays at manhole. - Less crew needed. **SPR TF/RO:** - Can splice spools together to line longer distances. - Only limited by hydraulic equipment distance capacity.	**Both:** - Cold weather can affect the PVC material. - Manufactured in Japan and Australia. **SPR EX:** - Both ends must be accessed. Needs to be torsionally restrained at receiving end. - Cannot "splice" spools together, so maximum distance of approx. 250 ft possible with this method. **SPR TF/RO:** - Production rates of approximately 75 ft per day. - Requires 2-3 entrants within the sewer for installation. This could pose a safety concern for long-reach installations.	- Typically installed downstream to upstream, but can do either direction. - Possible to "skip" manholes and reestablish them after lining several reaches - 50 year design life. - 12 week lead time from time of purchase to delivery - Finished ID of 34.3 inches. - 24 month product warranty from date of manufacture.	36" SPR TF: $349.62/LF	Yes, at WRC (9/6/2023)	Recommended for consideration in the design phase

	CURED-IN-PLACE PIPE (CIPP) PRODUCTS										
13	Felt or Fiberglass CIPP (DVM, Inland, InSitu Form, SAK)	Lining method by insertion of a resin-impregnated flexible lining through existing manhole structures that is cured in place against the existing pipe to form a new pipe liner.	Utilize existing manholes, may require modification of cone section (manufacturer claims they do not need modification)	Aggressive cleaning to remove loose material or any protrusions on pipe wall, infiltration above weeping would need to be addressed prior to application. Cleaning possible to open up additional infiltration. (Insituform states that only gushers with pressure need to be sealed).	Yes, full bypass required during preparation and application. Probably 10-12 inch diameter fused HDPE.	- Readily available with local manufacturers/installers. - Possible to line through manholes and reinstate afterwards. Could go approx. 1000 ft in each direction of access location if a field wetout application is used. - Laterals can be reinstated robotically within the pipe. - Can navigate 45-degree turns or less.	- Water trapped in sags a potential installation problem for liner curing. - Laterals need approx. 30 hrs of backup time before they can be reinstated if not bypassed. - Liner is transported in reefer trucks which may be difficult to reach offroad locations. - Require 45' x 25' pad around manhole for access, along with a 10' wide access road to reach the MH (SAK says 100' x 20'). - Styrene is a current environmental concern. Resins can be produced that are styrene-free but will be more costly.	- Standard CIPP thickness is 18mm to 24mm, Premium Composite thickness 15mm to 18mm (uses carbon fiber reinforcement). - Sags can be addressed during installation by performing a water based installation (instead of steam) and inverting the liner slowly to push out the water from the sags. Can also increase cure times to ensure all areas are cured. - Approx. 12 hours of cure time once up to temp for 500 ft section. - Tube manufactured in Mississippi, wet out in Indianapolis is current plan. - Insituform identified 19 manholes to be accessed. - 3-4 weeks of lead time required for liner production. - Depending on bypass, could line 2 sections per week. - Warranty: standard 1 year, max 5 years materials and labor. - SAK provided an estimate of $6.5 - $7 million for the entire project.	SAK: $213.41/LF Insituform: $400/LF - $450/LF (materials and installation) SAK provided an estimate of $6.5 - $7 million for the entire project.	Yes, at WRC (Insituform: 8/22/2023, SAK: 9/6/2023)	Recommended for consideration in the design phase
14	SippTech	Manufactured-in-place Composite Pipe (MICP). Robotically installs a composite liner within the host pipe. Currently can only be performed in 48-inch diameter pipes or above.	Utilize existing manholes				Minimum diameter restrictions of 48 inches.			No	Not recommended due to minimum diameter restrictions
15	IPEX / NovaForm PVC	Expand-in-Place PVC liner (fold-and-form). Product heated and then pulled into place with winch. Steam is then used to "inflate" the product into a tight-fitting liner.	Utilize existing manholes. Need to access upstream and downstream ends of each lining segment.	Jetting to remove settled debris and obstructions. Sealing of heavy gushing and running infiltrations. Water will most likely need to be removed from any sags prior to installation.	Yes, full bypass pumping required	- HQ in Canada. Manufactured in both Canada and US. - Have lined through 90-degree and 45-degree turns in the past. - Approx. half a day to line each A to B setup. Can perform about 2 setups per day (~100 feet/min. install rate). - Able to reinstate blind taps robotically from within the pipe. - Possible to pull through a manhole and cut off top of the liner later, if pulling distances allow. - Once the liner is hard, there is no shrinkage.	- Currently have only lined 300-400 feet at a time. The HRSDS has several reaches of 500+ ft lengths. Awaiting further information from the manufacturer. This may impact the ability to use this product. - Have to use a 30" diameter liner that "overexpands" into the 36" host pipe. Thicker 30" will be required due to the section loss caused by the expansion, may impact structural capacity. - Footprint required includes boiler truck and conditioning box (typically on flatbed semi trailer, but can be moved) at upstream end, and winch at downstream end. - Need to access almost every manhole due to limitations of pulling lengths. Long lining segments not probable with this product. - Most likely only able to perform MH to MH installations.	- Similar to CIPP, any defects visible in host pipe will be visible in liner (sags, offsets, etc.) - Pre heating temps of 180-200 degrees F. Relaxation period of ~30 mins after pulled into place. Condition for 1 - 1.5 hours with steam to "cure" and expand it into final shape. - Hydrophillic gasket installed in host pipe at both ends. - No bonding to host pipe, held by friction. Ends of the liner are flared out to help hold in place. - 1 year manufacturer warranty. - Similar cost overall to CIPP according to rep. - Can use ASTM 1504 or 1871 liner types depending on structural properties required.		Yes, at NTH (8/23/2023)	Not recommended due to installation distances
16	Thermoform PVC	Fold-and-Form PVC liner. Dropped out due to pipe depth limitations.					Maximum depth restrictions of 10' to 12'			No	Not recommended.
17	Rigid Seal	The RigidSeal Pipelining System consists of a moisture-activated, structural expanding polyurethane grout and a customized thermoplastic liner. The grout fills and seals the cracks and voids between the host pipe and the liner.	Utilize existing manholes, require removing at least the casting, possibly the whole cone section.	Aggressive cleaning to remove loose material or any protrusions on pipe wall, gushing infiltration would need to be addressed prior to application. Aggressive cleaning possible to open up additional infiltration.	Yes, full bypass required	- Chemical grouting of minor leaks not required prior to lining. - Liner does not stretch or shrink. - Modular installation footprint. Only things needed at installation manhole are funnel, liner reel, grout container, and air pressure source. Opposite access only needs winch. - Welding facility is in Detroit. - Laterals can be reinstated from within the liner. - NSF certified. - Thickness of liner set at approx. 0.25" - Water can be left in sags. - Can be lined either upstream or downstream. - Installation time of 15-20 feet per min.	- Experimental in nature. Currently have only performed up to 18" diameter lining. Possible to weld up to 48" diameter, but do not have funnel to install anything bigger than 24" at time of presentation. - Have only lined a maximum distance of approx. 320 ft to date (using 12" liner). - No industry standards for design or compressive strength. - Circumferential cross cuts weaken axial strength. May be possible to remove the cross cuts and add kevlar to longitudinal grooves.	- "Wet out" of urethane grout occurs in the field. - Liner is installed and then inflated with air pressure, no heat or steam cure required. - Pressurized time is approx. 6 - 10 hours for urethane to set up (longer times in cold weather). - Expansion ratio between 3:1 and 5:1. - Working gel time is approx. 45 mins. - Thermoplastic is manufactured as a continuous weld for each liner segment.		Yes, at WRC (8/30/2023)	Not recommended. Refer to Lining Rehabilitation Options for further details.
	GROUT-IN-PLACE LINER (GIPL) PRODUCTS										
18	Grout-In-Place Spiral Wound (SPR) - Sekisui	A traverse winding machine travels the length of the pipeline while constructing a steel-reinforced pvc liner at a fixed diameter. The annular space is then grouted.	Utilize existing manholes	Jetting to remove settled debris and obstructions that could interfere with lining. Spacer installations typically need to be installed in the host pipe to act as bracing during annulus grouting operations.	Can be installed in live flow if flow is 20-30% of cross sectional area and low velocity (2-3 cfs). Can release flow at end of work day. Grouting will require bypass pumping.	- Can be installed in existing manholes with no modification. - Possible to be installed in live flow. - Fully structural. - Able to navigate offsets, sags, and bends less than 15 degrees at manholes. - Minimal footprint (as little as 10' x 10'). Just need spool and generator topside, most of the work is within the pipe.	- Not recommended by Manufacturer for this project. Manufacturer instead recommends tight-fitting groutless option. - May require internal bracing until completion of grouting.	- Typically installed downstream to upstream, but can do either direction. - 50 year design life. - 12 week lead time from time of purchase to delivery - 24 month product warranty from date of manufacture.		Yes, at WRC (9/6/2023)	Not recommended.
	SPRAY-ON LINER PRODUCTS										
19	Geopolymer Liner, Epoxy Liner, Urethane Liner, Composite Liner, FRP Wet Layup Liner, Other	Spay-on coating or hand application	Utilize existing manholes	Aggressive cleaning to remove loose material on pipe wall, infiltration would need to be addressed prior to application	Yes, full bypass required during preparation and application		- Heavy surface preparation could reduce wall thickness further and potentially create additional running and gushing infiltrations. - Humidity control required for spray-on liner curing would be difficult to maintain. - 100% bypass required. - QC such as pull tests, etc. would be very difficult to perform in a 36" diameter pipe.	- Surface preparation is critical to achieve a good bond and long-lasting liner performance.		No	Not recommended.

Note: The information tabulated above is based on our experience with these products, discussions with product representatives, as well as data collected from product websites.

6.0 SEWER REHABILITATION OPTIONS EVALUATION AND DESIGN CONSIDERATIONS

6.1 REHABILITATION VS NEW CONSTRUCTION

In general, sewer rehabilitation and new construction represent two distinct approaches to addressing the wastewater infrastructure needs of a community, each offering its unique set of advantages and drawbacks. Selecting between sewer rehabilitation and new construction should be a thoughtful decision, taking into account the specific needs of the system under consideration. Factors such as budget constraints, the condition of the existing infrastructure, environmental and site condition concerns, anticipated design life, and future capacity requirements all play a pivotal role in determining the most suitable approach. As part of the BOD, we also considered two "new construction" options to compare with the liner rehabilitation technologies described in the previous section and are described below.

Pipe Bursting - Another trenchless lining option considered was Pipe Bursting. Pipe Bursting is the use of an expanding pulling head through the existing pipe to push out radially and break apart the host pipe, while also dragging in a new liner to replace the now-burst host pipe. This method is used to install similarly sized or larger diameter lining options when maintaining or increasing flow capacity is a factor. Based on the current hydraulic analysis of the HRSDS system, there is no design requirement to maintain or increase capacity of the system. It also would require significant effort to burst a 36-inch diameter reinforced concrete pipe and many methods for pipe bursting would not be able to burst a pipe of this size. There is also additional concern that pipe bursting efforts could disrupt other nearby utilities along with the potential to cause heaving underneath major road and railroad crossings. Additionally, the railroad crossings in which steel casings were installed and the pipe was jacked underneath the railroad would not be possible to burst. As such, we do not recommend the pipe bursting method as the host pipe, even with observable section loss, still provides support against soil loading and groundwater infiltration for other methods of lining rehabilitation.

New Sewer Construction - Construction of a new sewer to replace the existing by traditional open cut methods will likely require obtaining new easements, installing new manholes, relocating tap connections and other nearby utilities, groundwater control by dewatering, clearing and constructing access roads through protected woodlands/wetlands, and bypass pumping. As such, construction of a new sewer will not be cost effective and will result in significant disruption to the environment. We also briefly evaluated installing a new sewer by means of directional boring. This could potentially be beneficial for limited reaches of the sewer by removing some of the sharp alignment changes in the existing host pipe. However, and similar to the factors associated with installing new sewer using open cut techniques, this option would also likely require acquisition of new easements, installation of new manholes, bypass pumping, unfavorable soil and groundwater conditions, and maintaining grade would make installation of new sewer by directional drilling challenging and costly.

Based on our preliminary evaluation, sewer rehabilitation when compared to new construction stands out for its cost-effectiveness, making it an attractive option. Additionally, this approach often results in less disruption to the community. It requires less excavation and construction in established areas, and no dewatering along the alignment, reducing the inconvenience caused to residents and businesses. Furthermore, sewer rehabilitation generally has a smaller environmental footprint as limits soil disturbance, thus aiding in the preservation of the local environment. Due to

the significant costs associated with new construction, we believe that rehabilitation of the existing host pipe is the more cost effective and less disruptive option.

6.2 LINING REHABILITATION OPTIONS

Based on the discussions so far, it is evident that this is a unique project that will be constructed in challenging underground and access conditions, to provide long-term protection to the existing sewer from corrosive conditions and extend the life span of the system. Two installation methods are proposed for the 12 lining products considered for this project. These methods consist of manhole-to-manhole lining which will require removal of the existing cone sections and replacement with a flat top configuration of manholes, and long reach installations which will require the construction of access shafts at pre-selected locations. Both manhole-to-manhole and long reach installation methods will require modification or removal of the existing channel at manhole inverts.

Due to access requirements, hydraulic capacity, and easement consideration, the approximately 16,700 feet of the HRSDS Novi Trunk Extension No. 1, Contract Nos.1 and 2 have been broken up into eight (8) sections for lining. These were discussed and agreed upon by the project team comprised of NTH, OCWRC, ASI, and AEW during the lining workshop held at the NTH Northville office on September 19, 2023. The following paragraphs summarize options to line each sewer reach.

Section 1: Manhole MH-45 (NOT 058002) to Manhole MH-35 (NOT 060002) – Starting at the upstream end of the HRSDS system, Section 1 spans approximately 3,995 linear feet from manhole MH-45 to MH-35. There are 10 manholes in this section excluding start and end manholes. Due to the various turns in alignment and number of lateral tap connections in this section, "manhole-to-manhole" lining is required. We recommend tight fit liners such as CIPP and SPR products in this section since they have the capability to reinstate lateral tap connections from within the sewer and can minimize excavations and surface disturbances. Specialty slip-liners that are able to be lined from existing 4-foot manholes are also feasible for this section. These products include Thompson Flowtite, Superlit FRP, Vylon PVC, ThreadLiner HDPE, and QuakeWrap Stifpipe. Refer to Appendix J for additional details.

Section 2: Manhole MH-35 (NOT 060002) to Manhole MH-25 (NOT 091012) - Section 2 consists of sewer reaches from manhole MH-35 to MH-25 and spans approximately 3,935 linear feet. This section includes 11 manholes excluding the start and end manholes, and only 1 lateral tap connection upstream of manhole MH-28 (NOT 085001). Since this section is relatively straight, "long-reach" installation using a maximum of 2 access shafts are recommended for this section. The pre-approved access shaft locations shall be at manhole MH-33 (NOT 085006) which is a drop manhole structure, and at the lateral tap location upstream of manhole MH-28. Note that access to manhole MH-26 for any lining solution will require a river crossing. Recommended slip-lining products for this section include Hobas, Thompson Flowtite, Superlit FRP, QuakeWrap Stifpipe, Vylon PVC, Fusible PVC, Spirolite HDPE, and Fusible HDPE. SPR Tight-Fit liners and CIPP are feasible for this section but are not recommended due to requiring significant access to each manhole, including access roads and possible manhole modifications. Refer to Appendix J for additional details.

Section 3: Manhole MH-25 (NOT 091012) to Manhole MH-18 (NOT 091005) - Section 3 consists of sections between manhole MH-25 and MH-18 and spanning approximately 2,157

linear feet. This section includes six (6) manholes excluding the start and end manholes, and no lateral taps. Due to the alignment changes, railroad crossings, and river crossings, "manhole-to-manhole" installation is required in this section. Manhole MH-23 (NOT 091010) will require a river crossing to access, and manhole MH-18 is a potential access shaft location for the following section. Although "manhole-to-manhole" installation is required for this section, specialty short-joint slip-liners are recommended for this section instead of tight-fit liner and CIPP due to its placement in between two slip-lining sections and efforts to maintain a consistent diameter between the sections for hydraulic considerations. Recommended slip-liners for this section of the sewer include Thompson Flowtite, Superlit FRP, Vylon PVC, ThreadLiner HDPE, and QuakeWrap Stifpipe. SPR Tight-fit liners and CIPP are feasible for this section, but not recommended due to their larger finished diameter compared to the slip-lining options, which defy the considerations to maintain a relatively consistent diameter for hydraulic efficiency. Refer to Appendix J for additional details.

Section 4: Manhole MH-18 (NOT 091005) to Manhole MH-15 (NOT 091002) - Section 4 consists of the reaches between manhole MH-18 and MH-15 and spans approximately 1,160 linear feet. This section includes two (2) manholes excluding the start and end manholes, and no lateral taps. Due to the relatively small bends at manholes, this section is recommended for "long-reach" installation method, with potential access shaft locations at manholes MH-18 and MH-15. It should be noted that manhole MH-16 (NOT 091003) is located within the river and as a result will be difficult to access. Recommended slip-lining products include Hobas, Thompson Flowtite, Superlit FRP, QuakeWrap Stifpipe, Vylon PVC, Fusible PVC, Spirolite HDPE, and Fusible HDPE. SPR Tight-Fit liners and CIPP are feasible for this section but are not recommended due to requiring significant access to each manhole, including access roads and possible manhole modifications. Refer to Appendix J for additional details.

Section 5: Manhole MH-15 (NOT 091002) to Manhole MH-14 (NOT 091001) - Section 5 is only one sewer reach between manhole MH-15 and MH-14, with an approximate length of 142 linear feet. This section includes 90-degree turns at both upstream and downstream manholes. As a result, lining this reach will require "manhole-to-manhole" installation. There is also a railroad crossing over this reach that will require coordination with LSRC. Based on the relatively short length of the reach, as well as it being a "manhole-to-manhole" installation, both specialty short-joint slip-lining products and tight-fit products are recommended for rehabilitating this section. These products include Thompson Flowtite, Superlit FRP, Vylon PVC, ThreadLiner HDPE, QuakeWrap Stifpipe, CIPP, and SPR. Refer to Appendix J for additional details.

Section 6: Manhole MH-14 (NOT 091001) to Manhole MH-8 (NOT 102004) - Section 6 consists of sewer reaches from manhole MH-14 to MH-8 and spans approximately 1,955 linear feet. This is a relatively straight portion of the alignment with the exception of a bend at manhole MH-12 (NOT 102008). As a result, manhole MH-12 along with manhole MH-8 have been selected for potential access shaft locations. It should be noted that manhole MH-8 will require a river crossing to access, however, a two-track trail near the Novi Dog Park could provide reasonable access up to the river crossing. There are five (5) manholes in this reach excluding the start and end manholes, and no lateral taps. Manholes MH-10 (NOT 102006) and MH-11 (NOT (102007) are not easily accessible due to swampy ground conditions and standing water. We recommend "long-reach" installation method for this section using slip-lining products such as Hobas, Thompson Flowtite, Superlit FRP, QuakeWrap Stifpipe, Vylon

PVC, Fusible PVC, Spirolite HDPE, and Fusible HDPE. SPR Tight-Fit liners and CIPP are feasible for this section but are not recommended due to requiring significant efforts to access to each manhole, including access roads and possible manhole modifications. Refer to Appendix J for additional details.

Section 7: Manhole MH-8 (NOT 102004) to Manhole MH-7 (NOT 102003) - Section 7 is one sewer reach from manhole MH-8 to MH-7, with an approximate length of 357 linear feet. This section includes 90-degree turns at both upstream and downstream manholes. As a result, lining this reach will require "manhole-to-manhole" installation. There is also a railroad crossing over this reach that will require coordination with LSRC. There is a blind tap in this section that enters from the offset MH-8A (NOT 102010). Due to the offset manhole and location of this tap, reinstatement will be relatively easier than the previous blind taps. Based on the shorter length of the reach, as well as it being a manhole-to-manhole installation, both specialty short-joint slip-lining products and tight-fit products are recommended for rehabilitating this section. These products include Thompson Flowtite, Superlit FRP, Vylon PVC, ThreadLiner HDPE, QuakeWrap Stifpipe, CIPP, and SPR Tight-fit liners. Refer to Appendix J for additional details.

Section 8: Manhole MH-7 (NOT 102003) to Manhole MH-0 (NOT 104003) - Section 8 consists of the sewer reaches between manhole MH-7 to MH-0 and spans approximately 2,949 linear feet. This section includes six (6) manholes excluding the start and end manholes, and no blind tap connections. Since this overall section is comprised of two relatively straight sections, with a 90-degree bend at manhole MH-5 (NOT 102001), long reach installations using a maximum of 2 access shafts are recommended for this section. The pre-approved access shaft locations shall be at manholes MH-5 and MH-1 (NOT 101001). Recommended slip-lining products include Hobas, Thompson Flowtite, Superlit FRP, QuakeWrap Stifpipe, Vylon PVC, Fusible PVC, Spirolite HDPE, and Fusible HDPE. SPR Tight-Fit liners and CIPP are feasible for this section but are not recommended due to requiring significant access to each manhole, including access roads and possible manhole modifications. However, the SPR Tight-fit liners and CIPP options are feasible between MH-1 and MH-0. Refer to Appendix J for additional details.

For the long-reach installations described in Sections 2, 4, 6, and 8, annulus grouting operations may require access to intermediate manholes within these reaches. The number, location, and scope of work at such manholes shall be optimized in the design phase of the project.

Although RigidSeal was not a recommended product for the overall lining program due to diameter and installation length limitations, the technology is promising and OCWRC requested to consider designating a single reach of the system between two manholes for rehabilitation using the product (if the product is deemed feasible), which has not been finalized yet.

6.3 ACCESS FOR LINING SEWER

Existing access along the subject portion of the HRSDS includes 49 manhole structures installed as part of the original construction. The existing manhole structures are typically four (4) feet in diameter and are setup as "doghouse" configurations with influent and effluent pipes at either end of the manhole. Manholes spacing throughout the alignment varies from about 26 feet to about 574 feet.

Many of the manholes can be accessed with minimal disruption to traffic, nearby businesses, and residences; however, there are several manholes located on opposite sides of the river, in wetland areas, or in heavily wooded areas that are not easily accessible. The manholes may serve as access/exit points for manned entry during lining operations though it is unlikely that lining products could be delivered to the sewer through these locations without significant clearing operations and/or modifications to the manholes themselves. As a result, access shafts will need to be installed at key locations throughout the alignment to perform lining operations.

Although one of our goals was to limit the number of access shafts and environmental disturbances, we believe the most cost-effective and efficient methods for lining longer reaches of the sewer would be to install no more than eight (8) access shaft structures at the locations described below. Due to the relative straightness of the alignment near the proposed 8 access structures, lining through multiple sewer reaches at once from each direction would be possible, thus eliminating the need to set up at each individual manhole. See the preliminary rehabilitation options in Appendix J for additional information. These locations were agreed upon with OCWRC during the lining workshop meeting on September 19, 2023.

Shaft Location No. 1: Manhole MH-1 (NOT 101001) - The proposed access shaft at manhole MH-1 would be used to line approximately 1,854 linear feet from manhole MH-5 to MH-1 and approximately 310 linear feet from manhole MH-1 to MH-0 (NOT 104003). The current rim to invert depth of manhole MH-1 is approximately 13 feet. This location is not within a wetland delineated area and is located within the right-of-way of the HRSDS easement. The use of an access shaft at manhole MH-1 would allow for the possibility to clear a large area and preparing/laying long portions of new liner on the surface. Additional temporary easements for both access roads to the manhole and for clearing a larger area surrounding the manhole may be required at this location.

Shaft Location No. 2: Manhole MH-5 (NOT 102001) - The proposed access shaft at manhole MH-5 would be used to line approximately 1,854 liner feet from manhole MH-5 to MH-1 and approximately 785 linear feet from manhole MH-5 to MH-7 (NOT 102003). The current rim to invert depth of manhole MH-5 is approximately 25 feet. This location is not within a wetland delineated area and is located within the right-of-way of the HRSDS easement; however, it is very close to the limits of the easement. As a result, additional temporary easement may be required at this location. Due to the proximity of the LSRC railroad ROW (approximately 150 feet), space to lay out long sections of liner may not be feasible at this location.

Shaft Location No. 3: Manhole MH-8 (NOT 102004) - The proposed access shaft at manhole MH-8 would be used to line approximately 1,573 linear feet from manhole MH-8 to MH-12 and potentially the 357 linear feet from manhole MH-8 to MH-7 (NOT 102003). The

current rim to invert depth of manhole MH-8 is 13.6 feet. A river crossing or railroad crossing will be required to reach this location. Additionally, note that manhole MH-8 is not located within the current HRSDS easement due to discrepancies between the alignment and the easement description at this location.

Shaft Location No. 4: Manhole MH-12 (NOT 102008) - The proposed shaft location at manhole MH-12 would be used to line approximately 1,573 liner feet from manhole MH-12 to MH-8 and approximately 382 linear feet from manhole MH-12 to MH-14 (NOT 091001). The current rim to invert depth of manhole MH-12 is 14.4 feet and is located approximately 16 feet from the edges of a wetland delineated area. Additionally, note that manhole MH-12 is not located within the current HRSDS easement due to discrepancies between the alignment and the easement description at this location.

Shaft Location No. 5: Manhole MH-15 (NOT 091002) - The proposed shaft location at manhole MH-15 would be used to line approximately 1,160 linear feet from manhole MH-15 to MH-18 (NOT 091005), and could also be used to line the approximately 142 linear feet from MH-15 to MH-14 (NOT 091001).The current rim to invert depth of manhole MH-15 is 16.5 feet and is located approximately 26 feet from the edges of a wetland delineated area. Additionally, note that MH-15 is located within the HRSDS easement, but only 20 feet away from the limits of the LSRC railroad ROW.

Shaft Location No. 6: Manhole MH-18 (NOT 091005) - The proposed shaft location at manhole MH-18 would be used to line approximately 1,160 linear feet from manhole MH-18 to MH-15 (NOT 091002) and potentially the approximate 197 linear feet from manhole MH-18 to MH-19 (NOT 091006). The current rim to invert depth of MH-18 is 12.9 feet and is located approximately 30 feet from the Walled Lake Branch.

Shaft Location No. 7: Tap Upstream of Manhole MH-28 (NOT 085001) – Access shaft location No. 7 is proposed at the lateral tap approximately 30 feet upstream of manhole MH-28. This location would be used to line approximately 1,147 linear feet from the lateral tap near manhole MH-28 to MH-25 (NOT 091012) and approximately 2,242 linear feet from the tap to the drop structure at manhole MH-33 (NOT 085006). The invert depth at the location of the tap 30 feet upstream from MH-28 is approximately 11.4 feet, and it is located within the existing HRSDS easement. The use of the lateral tap location instead of directly at manhole MH-28 would be beneficial in order to avoid an additional excavation to reinstate this tap connection after the completion of lining. This location would also be beneficial to split up the lining distance of 3,388 linear feet from manhole MH-33 to MH-25.

Shaft Location No. 8: Manhole MH-33 (NOT 085006) – Access shaft location No. 8 is proposed at the manhole MH-33 drop structure and will be used to line approximately 3,388 linear feet to manhole MH-25 (or 2,242 linear feet to proposed access Shaft Location No. 7) and approximately 546 linear feet to manhole MH-38 (NOT 060006). The current rim to invert depth of MH-33 is 25.6 feet and is located approximately 15 feet from the edges of a wetland delineated area. Manhole MH-33 is also located within the easement of the HRSDS ROW.

Note that the number of access shafts to be used, if any, depends on the lining products used in the final rehabilitation. The construction of the access shafts may vary from soldier pile and lagging shafts to trench box installations depending on the preferred configuration and shaft depth, as well as soil and groundwater conditions at each location. We recommend supplemental geotechnical investigations at each access shaft selected as part of the design phase of the project. We also recommend an environmental study at 5 of the shaft locations where PEC had been identified near these locations. A dewatering system may be required at these access shaft locations depending on the results of the supplemental geotechnical investigations.

6.3.1 Access Road, Laydown Area Requirements, and Easements

The HRSDS largely follows the alignment of both the Lake State Railway and the Walled Lake Branch River. Both the railroad and the river create difficult access requirements for reaching many of the manholes within the sewer alignment. In order to reach certain manholes such as MH-8 (NOT 102001), MH-23 (NOT 091010), and MH-26 (NOT 090001), either river crossings or railroad crossings would be required. Additionally, other areas along the alignment including manholes MH-10 (NOT 102006), MH-11 (NOT 102007), and MH-16 (NOT 091003) are all located either within the standing water in the river, or in swampy conditions that are difficult to reach for construction operations. Areas delineated as wetlands also factor into the ability to construct access paths and pads at certain manholes. As a result, rehabilitation methods that can be performed without the need for heavier equipment access to each individual manhole are preferred.

However, construction of the proposed sewer rehabilitation project for the HRSDS will require access to virtually all of the existing manholes. In some cases, access will be required for a limited time only with minimal physical work being performed with light equipment. However, it is envisioned that a substantial number of the manhole sites will require physical work to be performed and will require extended periods of occupation, potentially as long as one month. Additionally, the majority of the sites will require special consideration for construction easement acquisition and will include easements (on public land and/ or private properties) for light to heavy vehicular travel to the site from the nearest public road. It is apparent that the establishment of access routes may likely be the most visible, disruptive, and generally objectionable aspect of the project to the community. As a result, basic design considerations that define easement locations, easement dimensions for both access and construction work will be addressed during the design phase. Conceptual details for the construction of the temporary work areas shall be included in the design documents.

The general approach to construction of access-ways should stress the importance of several significant concerns:

- Ease and speed of construction, and similarly, ease and timeliness of removal when required. Restoration of the affected areas must commence as soon as the site is vacated, unless affected by seasonal limitations.
- The use of traditional methods for temporary access-way construction which employ imported re-cycled aggregate or other base materials should be avoided as the in-kind restoration of the work area may be difficult to achieve as well as creating a much greater adverse environmental impact. As options for access-way construction, the marketplace offers a wide variety of temporary road and path mats intended for use in supporting construction activity over poor soil conditions. These products are constructed of timber, recycled plastics, or other materials, and

are offered by such firms as GreatMats, Bridgewell Resources, and Spartan Mats, and typically are available as a purchase item or optionally on a rental/lease basis. The mats also provide for rapid deployment where needed and are easily recoverable for further use where needed. Following removal, restoration of the affected site is faster and generally less invasive, particularly in vegetated areas.

Noting that in isolated cases, disruption of the existing natural habitat is unavoidable when construction access is absolutely necessary. In such instances, restoration to an "as good, or better" condition is mandatory, and the project budget should include funding for restoration of particularly sensitive areas to the "or better condition." A variety of options may be considered as to the disbursement of this budget for the benefit of the project. These options may include a project lump sum allowance to draw from (published or unpublished), an established bid price for restoration of each site to minimum standards, or other variations that ensure the project is completed without permanent restoration scars. There also may exist innovative options that promote the protection of the existing landscape by requiring the Contractor pay for each natural feature (such as trees removed), or square yards of additional landscape disrupted beyond plan limits.

Certain easements, or in some cases a written "simple right of entry" permission granted from private landowners, may allow for alternative means of accessway construction that are consistent with the affected area and are also acceptable to the landowner. An example may be the extension of an access-way from an existing gravel storage lot whereupon the lot improvement and accessway remain in place permanently to the satisfaction of the landowner. Such agreements must be well defined in advance and documented with copies of the executed agreement provided to the Engineer and Project Owner.

In numerous locations, the stewardship of the immediate physical environment will be of utmost importance from regulatory requirements as well as demonstrating the normal "care and custody" of existing natural features. The impact on the public perception and voiced opinion of the project will require careful attention to the performance of the work in terms of the avoidance of construction activity that is poorly planned, slow to progress, carelessly managed, or inattentive to the care of existing features (i.e., disruption of wetlands, mature forested areas, soil erosion management, Threatened and Endangered Species). This would undoubtedly make the acquisition of additional access agreements very challenging.

For locations where river crossings are unavoidable (such as access to manholes MH-8, MH-9, MH-10, MH-23, and MH-26), EGLE and other applicable regulatory agency permitting requirements shall be applied in the design and construction of the project. This may include, but is not limited to, avoiding the placement of supports within the river and the floodway when constructing crossings.

The Lake State Railway is an intermittent, but frequent parallel "neighbor" of the project, and should be brought into the planning and project management aspect of the design phase. This aspect is of particular concern where the existing sewer crosses under the railroad, where temporary construction crossings over the tracks might be required, or other activities falling under stringent railroad protocols may occur. As such, the design requirements and construction shall follow all LSRC permitting requirements when working within their ROW.

Furthermore, it is likely that a substantial laydown area will be required for the temporary storage of lining materials that presumably will be received in large quantities. The immediate project vicinity would appear to offer opportunities for such areas; however, early planning and investigations may be necessary to afford time for easement verification and or acquisition, lease arrangements, and similar requirements. Considering the above, the design should also consider including a topographic survey of the key features along the existing sewer alignment to understand as-built location, current grades, and surface features. Moreover, the design phase shall include geotechnical investigation, subsurface utility engineering, environmental investigation, and topographic and wetland/endangered species survey at each potential access location and temporary access path along the alignment.

6.3.2 Supplemental Subsurface Geotechnical Exploration

For the eight (8) proposed shaft/excavation locations, it will be necessary to understand the soil and groundwater conditions that currently exist at these locations in order to properly design the temporary earth retention systems (TERS) and dewatering systems that maybe required. For that issue, NTH completed a gap analysis by reviewing the available geotechnical information from the historical test borings and from the initial geotechnical exploration that was performed for the void/loose soils investigation.

Review of the available geotechnical data from previous investigations performed in 1968 and 1970 included soil borings that provide some indication of the subsoil and groundwater condition in the general area along the sewer. We also reviewed the latest test borings that NTH performed as part of the void and loss soil exploration; however, the closest borings are located at distances ranging from about 100 to 660 feet away from the potential shaft/excavation locations. In addition, the geotechnical data from the 1968 and 1970 historic explorations provided only limited information such as the types of soils and limited laboratory testing (some without SPT data), but the data is not sufficient for a complete understanding of the subsurface conditions above and below the sewer for design of TERS and dewatering system. Also, the historic soil borings were too shallow for the purpose of analyzing bottom stability associated with design of the TERS. Moreover, the available laboratory tests did not include grain size analysis in order to determine the appropriate methods to dewater such soils. As such, the available data will not be sufficient to provide appropriate site-specific soil and groundwater conditions that currently exist at these eight potential shaft locations.

In addition, during the lining and bypass pumping planning, NTH identified one location (MH-8; NOT 102004) where the contractor may need to cross the river to access the potential shaft/excavation location. For such crossings, it is anticipated that the contractor may utilize temporary bridging, such as heavy matting, steel road plates or similar methods, to allow for equipment or piping to access and bridge the river. In order to provide the contractor with geotechnical data to allow him to properly select the temporary crossing to adequately support his equipment, it will be necessary to conduct geotechnical exploration at these locations. Also, it may be necessary to cross the river to lay piping for the bypass pumping at some locations. However, we anticipate that the river crossing for bypass pipes would only need narrow bridging such as wide flange beam or similar arrangement that may not require additional geotechnical exploration.

Therefore, as part of the design of the project NTH recommends that site specific geotechnical exploration be performed at these locations. Attached in Table 5 below is a tabulation of the proposed test borings along with potential soil and groundwater conditions (based on historic borings and recent NTH test borings). However, since there is uncertainty in the actual number and locations where other temporary river crossings are necessary depending on the means and methods selected by the contractor, considerations for additional geotechnical explorations shall be addressed during the design phase.

Table 5: Proposed Test Borings at Possible Shaft Locations

HRSDS Novi Trunk Extension No. 1 Contract Nos. 1 and 2 Rehabilitation Project

Proposed Test Borings at Possible Shaft Locations

Boring No.	Near MH	Location Access	MH NORTHING	MH EASTING	MH rim to invert, ft	Closest Historical TB	Soil Type	Groundwater Depth Below GS, ft	Assumed Shaft Depth, ft	Potential Depressurization Zone, ft	TB/HAB Depth, ft	Piezometer?	Nearby properties	Phase 2 Env Required
TB-6	NOT 101001 (MH No. 1)	Access to MH-1 is proposed via the 41626 Chattman St. residence. Mats will be required to minimize disturbance to the yard. Small diameter trees near the manhole will beed to be removed via chainsaw in order to get approx. 10 feet from the manhole for a test boring. Larger diameter tagged trees in the vicinity will not need to be desturbed. Residence at 41626 Chattman St. to be notified.	351228.41	13368596.66	13.45	TEC SB #1 approx 170' W of MH No. 1	Clay underlain by sand within the sewer zone	2.5	15.5	14.0	25	Y	Residential approx 150' to the south	No
TB-7	NOT 102001 (MH No. 5)	Access to MH-5 shall be via Harada Industry of America's west parking lot. The parking lot can be reached from Venture Dr off of 9 Mile Rd. Minor brush will need to be hand cleared. Harada and Durr Systems (parcel owner) to be notified prior to investigation.	351078.46	13366750.96	26.17	TEC SB #3 approx 350' N of MH. No. 5	Mostly Clay	3.5	28.0	None	40	N	Large commercial building approx 100' to south	No
TB-8, HAB-1 and HAB-2 (on both sided of river)	NOT 102004 (MH No. 8)	There are two options for accessing MH-8: 1) Use the existing utility road and cross the river to perform soil boring. Hand augers should also be performed on either side of the river for potential river crossing during the construction phase. Explore with drillers the possibility of crossing the river with rig monted on large rubber tires vehicle. 2) Obtain a railroad crossing permit from LSRC to cross the railroad from the east of the manhole. Access would be possible from the south parking lot of Durr Systems. Small diameter tree clearing may be required near the manhole. Durr to be notified prior to the investigation. Regardless of the selected option, the parcel owner (Novi Ten Associates) is to be notified prior to the investigation.	351808.29	13366366.30	13.60	MDC SB #4 approx 100' E of MH No. 8	Mostly sand	5.5	15.5	11.0	TB to 25 ; HABs 1 and 2 and DCPs as deep as possible, min 6 '.	Y	RR approx 40' to the east, and multi family residential approx 400' to the east	Yes
TB-9	NOT 102008 (MH No. 12)	MH-12 can be accessed from 10 Mile Road with no clearing required for the investigation. There is a small tree directly in front of the manhole, but the boring can be offset by approx. 10 ft to leave the tree intact. There is also a large hill that can be avoided by taking a smaller footpath around the hill. The parcel owner (Novi Ten Associates) to be notified prior to investigation.	353353.09	13366100.57	14.40	MDC SB #6, approx 420' N of MH No. 12; TB-1 approx 350' N of MH. No. 12	Mostly Sand	20' at MDC SB #6; 15' at NTH TB-1	17.0	3.0	30	Y	RR approx 100' to the east, and large commercial building appro 400' to the SE	Yes
TB-10	NOT 091002 (MH No. 15)	MH-15 can be accessed directly from 10 Mile Road. It should be noted that there is a fence that runs parallel to 10 Mile near this location, however the fence ends near the LSRC RR with enough room to access the manhole with investigation equipment. The parcel owner (City of Novi) to be notified prior to the investigation.	353751.36	13366242.15	16.50	MDC SB #6 approx 100' W of MH No. 15; TH-1 approx 140' W of MH No. 15	Mostly Sand	20' at MDC SB #6; 15' at NTH TB-1	19.0	5.0	30	Y	RR approx 50' to the west, and commercial building approx 150'to the NW	Yes
TB-11	NOT 091005 (MH No. 18)	In order to access MH-18 an excavator will be required to clear trees and thick brush in order to reach the trail head of a small footpath that leads to the manhole. It appears that the footpath is large enough to reach the manhole with investigation equipment. Both Guhring and the parcel owner (City of Novi) to be notified prior to the investigation.	354795.85	13365793.82	12.90	TEC SB #4 approx 500' NW ofMH No. 18	Mostly Sand (TB too short)	4.0	15.0	12.0	25	Y	Residential appro 250' to the east, commercial building approx 250' to the north, and RR approx 100' to the west	Yes
TB-12	At tap 29.5 ' N of NOT 085001 (MH No. 28)	MH-28 can be accessed from 25345 Novi Road facility without significant clearing. It should be noted that there is a fence around the rear of the facility that may limit access around the southwest side, however it is possible to reach the investigation area by going around the northeast side of the building instead. The parcel owner (RLA Ventures, LLC) to be notified prior to the investigation.	357015.72	13363699.38	11.40	NTH TB-5 approx 100' E of MH No. 28: and MDC SB #11 approx 100' SE of MH No. 28	Layered clayey and sandy soils. Sandy throgh the sewer zone	9' at TB-5 and 6.2' at SB #11	13.5	8.0	25	Y	Commercial building approx 100' SW, RR approx 75' to the east	Yes
TB-13	NOT 085006 (MH No. 33)	MH-33 can be accessed through the backyards between the two residences at 25847 and 25855 Trestle. Mats to be used in yards, and minor clearing of small diameter trees required with chainsaw to access the manhole through the woods. The residences along with the parcel owner (CSX Transportation) are to be notified prior to the investigation.	357623.00	13362301.26	25.60	MDC SB #12 approx 660' SE of MH No. 33	Mostly Clay	none	28.0	None	40	N	Residential appox 100' to the west, RR approx 80' to the east.	No

The exploration for the temporary shaft/excavation locations would include drilling of soil borings at each location to adequate depths for design of temporary earth retention system (TERS, shafts/excavations), collection of soil samples, installation of open stand pipe monitoring wells at locations where predominantly water-bearing sandy soils exist to obtain future groundwater data, performing laboratory testing to define the soils' engineering properties and design parameters and to develop soil profile for the design of the TERS. With respect to the river crossings, NTH recommends that the geotechnical exploration consist of performing hand auger borings (HABs) and Dynamic Cone Penetrometer (DCP) testing near the crest of the river (both sides of the river) to explore the conditions at these locations. This will provide the contractor with soil composition as well as the bearing capacity of the near surface subsoils at these locations.

In addition, in the event that the subsurface conditions consist of mostly sandy soils with a high groundwater table, it may be necessary to conduct additional investigations at such locations to collect additional data that pertain to the conductivity of such soils for dewatering. These may include slug testing using the open pipe monitoring wells. It may also be necessary to conduct one or more site specific pump tests at specific locations to obtain adequate information for the contractor to design his dewatering system.

At the completion of our exploration and analysis, a Geotechnical Report would be developed for use during design, which will provide documentation of the investigation data, summary of subsurface conditions, and evaluation of conditions with respect to the proposed design and construction. This report will then be included in the Contract Documents.

6.3.3 Supplemental Subsurface Environmental Exploration

Based on our preliminary environmental corridor study conducted as part of the BOD, five (5) out of the proposed eight (8) locations identified for access shaft construction is recommended for a Phase II Environmental Site assessment (ESA) to evaluate those recognized environmental conditions at excavation locations. The locations include manholes MH-8 (NOT 102004), MH-12 (NOT 102008), MH-15 (NOT 091002), MH-18 (NOT 091005), and at a tap location north of manhole MH-28 (NOT 085001). The results of the site assessment will define the severity of contamination, if any, and assist in preparing construction due care guidelines, including soil management and disposal procedures, and recommendations for project contractors to develop appropriate health and safety plans prior to initiating subsurface construction work.

Phase II ESA will be comprised of drilling soil borings, collecting soil and groundwater samples, chemical analysis of representative samples, evaluation of field and analytical data and preparation of a report with our recommendations. A written report documenting compiled information along with recommendations will be included in the Contract Documents.

6.3.4 Supplemental Wetland, Threatened and Endangered Species Exploration

Wetland – As indicated earlier, wetland boundaries within a 60-foot-wide corridor along the alignment of the HRSDS were flagged as part of the BOD study. According to Part 303 Wetlands Protection of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 303), wetlands regulated by the State of Michigan include wetlands that are:

1. Located within 500 feet of, or having a direct surface water connection to, an inland lake, pond, river, or stream; or
2. Greater than 5 acres in size; or
3. Located within 1,000 feet of, or having a direct surface water connection to, the Great Lakes or Lake St. Clair; or
4. A water of the United States as that term is used in section 502(7) of the Federal Water Pollution Control Act, 33 USC 1362; or
5. Known to have a documented presence of an endangered or threatened species under Part 365 of State of Michigan 1994 PA 451, as amended or the Federal Endangered Species Act of 1973, Public Law 93-205; or
6. Rare or imperiled.

It appears that all of the wetlands delineated are regulated under Part 303 because they are located within 500 feet of, or have a direct surface water connection to, an inland lake, pond, river, or stream. Therefore, a Part 303 permit would be required from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) in most instances to place fill or structures, remove soil, drain surface water from, or make use of any regulated wetlands identified.

Many of the wetland areas include river or stream segments. Specifically, those associated with the Walled Lake Branch of the Rouge River and its tributaries. These features would be regulated by the State of Michigan according to Part 301 Inland Lakes and Streams, of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 301). Therefore, a Part 301 permit would be required from EGLE in most instances to place fill or structures within, to dredge below the ordinary high-water mark of, or to place structures above or below the stream channel.

The initial wetland delineation was for a 60-foot corridor along the sewer alignment. It is expected that due to access and bypass requirements, as well as the final rehabilitation options, further refinement to the wetland study will be required during the design phase depending on the final rehabilitation option, construction access and bypass requirements, and their impact on such wetlands. These may include additional wetland delineations, seeking EGLE or City of Novi confirmation of wetland boundaries and jurisdiction thereof, attending any meetings, and preparation of permit applications.

Threatened and Endangered Species - Based on the desktop review, it is recommended that impacts to the identified protected species are avoidable if work is performed between November 1 and March 31. However, if work is performed between April 1 and October 31, the following are recommended:

- Perform a visual inspection for nests within vegetated areas subject to ground disturbance for work between April 15 to August 15.
- Install wildlife safe exclusionary fencing to prevent Eastern Massasauga Rattlesnake (EMR) and Blanding's Turtle from accessing the work area.
- Review the Eastern Massasauga Rattle Snake (EMR) flyer (attached to the Threatened and Endangered Species Evaluation Memorandum included in Appendix H) prior to construction.

- Complete consultation for Indiana Bat and Little Brown Bat with USFWS and MDNR, respectively, for tree removal between April 15 and September 30. If tree removal will impact greater than 10 acres of contiguous forest or fragment two or more forest patches greater than 5 acres, further review of the proposed tree removal extent and potential consultation with USFWS for Indiana Bat and Northern Long-Eared Bat (NLEB) is recommended.

If federal nexus is anticipated. concurrence of the NLEB "may affect, not likely to adversely affect" determination is recommended with the federal action agency. If any protected species are encountered during project activities, it is recommended to not handle, harm, or harass the individual and report all sightings to the appropriate agency within 24 hours.

Further refinement to the desktop study will be required during the design phase depending on the final rehabilitation option and access routes and their impact on such Threatened and Endangered Species. This may include on-site protected species investigations, agency consultation, attending meetings, seeking regulatory agency consultation, and/or preparing permit applications.

Moreover, our review indicates that certain proposed shafts and existing manholes may be located within the 100-year flood plain and will potentially impact EGLE regulated floodplains/floodways. Therefore Part 31 permit application will be required.

6.4 THEORETICAL MINIMUM LINED PIPE DIAMETER

The theoretical minimum diameter of lined pipe was determined for each reach where the full pipe capacity was still greater than the model predicted 25-Year, 24-Hour design event flow rate and is presented in Table 6. These minimum diameters were taken to the nearest inch, however, depending on the lining methodology selected, only certain sizes may be commercially available. It is important to understand that the minimum lined diameters will limit the capacity for future development in the tributary service areas of the rehabilitation reach.

Table 6: HRSDS Minimum Lined Diameter by Reach

Reach	Upstream GIS Facility ID	Downstream GIS Facility ID	Existing Diameter (in)	Minimum Allowable Lined Diameter (in)	Resulting Full Pipe Capacity (cfs)
1	NOT 058002	NOT 060005	36	24	7.8
2	NOT 060005	NOT 085006	36	24	14.9
3	NOT 085006	NOT 085002	36	25	9.6
4	NOT 085002	NOT 091007	36	25	20.2
5	NOT 091007	NOT 102002	36	25	16.4
6	NOT 102002	NOT 101003	36	26	15.7
7	NOT 101003	NOT 104003	36	26	20.7

6.5 SPOT REPAIRS

Based on review of previous CCTV inspections, numerous infiltration locations were noted along the alignment. The 2022 post-grouting CCTV inspection noted that the running and gushing infiltrations

within the 10 Mile crossing were sealed, with 4 weeping infiltrations remaining. Additionally, there were two (2) locations along the HRSDS Contract No. 1 and 2 alignment where running infiltration was encountered in the 2022 re-inspections.

Soil conditions surrounding the sewer can have a large impact on the importance of sealing active infiltration and the potential for void development around the sewer. Based on our evaluation history of unreinforced interceptor liner failures in the other systems, the primary cause of such failures, has been attributed to open cracks or joints in the unreinforced liner, combined with a high groundwater table and silt/fine sand surrounding the liner, allowing excessive amounts of fines to be piped through the lining into the interceptor. This process created voids and removed outside support of the sewer in certain failure areas, resulting in collapse of the sewer.

It is anticipated that it will be necessary to seal any running/gushing infiltration prior to the sewer lining operations taking place. As such, during construction if the contractor notices any existing/new runners/gushers (considering the time lapse between the last CCTV inspection and when construction is going to commence in 2024 summer, tentatively) that we had identified, and any additional infiltration that may develop as a result of the pipe surface preparation/cleaning operations, the contractor shall address those utilizing chemical/cementitious grout to seal them prior to lining. Chemical grouting, cementitious surface grouting, and additional spot repair items that may be encountered prior to lining operations such as concrete repairs, debris removal, and manhole repairs are discussed in the following sections.

6.5.1 Chemical Grouting

For the HRSDS, chemical grouting should be used to seal leaks at localized running infiltration at joints and as needed for liner surface preparation prior to liner rehabilitation. For leak sealing of running infiltration at joints, if the soils are anticipated to be predominately cohesive in nature, only the chemical grouting will be used. However, if the chemical grout takes are excessive, the process will shift to cementitious grouting. Chemical grouts are anticipated to be primarily acrylamide, fed from a grout truck at the ground surface with separate lines for the acrylamide and the catalyst, which are then mixed at the point of injection. Urethane grouts can also be utilized but temperature requirements for specific products should be verified before use.

6.5.2 Cementitious Surface Grouting

The most cost-effective method to fill a large void formed by soil piping is through cementitious grouting. Due to the smaller 36-inch diameter of the HRSD, cementitious grouting from within the sewer is not feasible. Instead, bore holes are drilled at the surface in pre-determined arrays and grout is pumped to fill the void. Injection pressure can typically range from 1 psi to 2 psi per foot of depth. Surface cementitious grouting details and bid quantities shall be included in the final design package as "engineer directed" repair details, depending on the results of supplemental geotechnical investigations that will determine if cementitious surface grouting is needed to fill loose soil conditions around the sewer.

6.5.3 Concrete Repairs

Localized patching is used to repair defects that are too small to warrant the use of a lining product (mainly at manhole locations), or to prepare the host pipe where defects would otherwise impede the potential lining operations. In reference to this project spot concrete repairs will most likely occur within manholes in preparation for lining or after lining to repair incidental damage. The localized patching is generally divided between shallow and deep repairs. Shallow repairs are typically 1 to 3 inches in depth. Deep repairs are deeper than 3 inches and where reinforcement has been used in the structure, reinforcement will typically be exposed in the patch area. Localized repair areas should have a saw cut perimeter and the area within the perimeter chipped to remove loose and damaged concrete. At the perimeter of the patch, the repair mortar must be applied in a thickness equal to or greater than the mortar manufacturer's minimum thickness but less than the manufacturer's maximum thickness. Surface preparation must also comply with ICRI requirements, as well as the mortar manufacturer's minimum requirements.

6.5.4 Debris Removal

Prior to the installation of lining material, the sewer should be cleaned to remove loose deposits and obstructions that may interfere with lining operations. Difficulty in access certain manholes located in heavily wooded or swampy locations should be taken into consideration during cleaning operations. The nominal distance a vac-truck can typically remove material is approximately 2,000 linear feet from the closest downstream manhole, although there is specialty trailer mounted equipment capable of a longer reach so that difficult to reach manholes do not have to be accessed directly. Typically, the vac-truck is positioned to the downstream side of the deposit to be removed. Such cleaning should be practical from many of the manholes along the HRSDS without removing the frame and cover, depending on the amount of debris to be removed and the equipment to be used. If desired, the existing cone sections could be replaced with a 4-foot diameter section of precast manhole riser and a flat top cover. The use of the flat top cover allows the manholes to be opened up to their full diameter for future cleaning with minimal excavation.

6.5.5 Manhole Repairs

As discussed earlier, NTH did not perform MACP inspection reports of each manhole as our primary objective was to document the tap connections and as-built configurations of the manholes. However, we did not observe any critical failures or defects that required immediate attention during our investigation. Minor defects that we typically observed across a majority of the manholes include the following: Surface aggregate visible, Fine roots, and Capped tap connections. Regardless, we recommend that any shallow concrete defects noted in the manholes be repaired as part of this rehabilitation project. As such, the contact documents shall include provisions for such repairs, and provide details for such shallow concrete defect repairs. In some cases, the manhole inverts may need to be temporarily modified by removing the flow channel in order allow for "through manhole" lining to proceed such as the case when lining long reaches of pipe. The contract documents should include provisions to repair such modifications.

6.6 BYPASS PUMPING

Since there are no permanent flow control structures along the HRSDS Novi Trunk Extension No. 1 alignment, bypass pumping operations will be required for uninterrupted flow during construction for any rehabilitation system that cannot be installed in live flow conditions. ASI produced conceptual bypass pumping routes for the sewer, including bypass required for lateral connections. The host pipe is required to be dry during the installation of most lining technologies. Three options for achieving this condition were reviewed for the HRSDS including diversion by gravity, in-system storage, and bypass pumping.

No existing diversion by gravity options were available for flows in the HRSDS nor were there any prospective opportunities for the construction of a new diversion. The closest neighboring system is the Evergreen Farmington Sanitary Drain Drainage District to the east which is about 1 mile away at its closest point to the HRSDS rehabilitation extent. Also, utilizing the available in-system storage in the upstream HRSDS is technically an option; however, the storage times in dry weather were found to range from 1 to 2 hours before the storage must be released. Such brief storage times were not considered a feasible option for accommodating any lining installation.

Bypass pumping in dry weather was selected as the most effective technique to achieve the dry pipe condition. As such, ASI developed a primary bypass setup, and sometimes an alternate, for each lining section as indicated in Table 7 below. Bypass is achieved by plugging the upstream and downstream ends of each lining section, pumping out of an upstream manhole and discharging into a downstream manhole.

Since the HRSDS generally follows the river, most of its extent is not located near public ROW for routing the discharge piping. Therefore, the resulting bypass routes needed to run through private property requiring temporary easements and which often is through swampy or heavily wooded terrain or alongside the Lake State Railroad. When possible, alternate routes that can utilize ROW are provided, however these routes will have road and driveway crossings that must be accounted for.

The bypass routes were assumed to be able to travel under existing bridges or through existing storm culverts to cross other major utilities such interstates, main roads, and railroads. Permission from regulatory agencies and the utility owner is required for such an activity.

Additionally, some blind tap (a.k.a. barrel tap) connections to the HRSDS pipe exist along the lining sections and were discovered during sewer televising. Similarly, other connections at HRSDS manholes that could not be attributed to a City of Novi sewer based on the GIS were also discovered during the sewer televising. Investigation of these blind taps and additional manhole taps is required to determine if they are active, and if so, whether an upstream manhole or clean out exists that could be used for a bypass setup. If active and no upstream structure exists, an investigation must be made to determine if the tributary property (or properties) can have their sanitary sewer put temporarily out-of-service.

The forcemain from Lanny's Pump Station at the intersection of Beck Road and Heritage Drive in the City of Novi discharges at the upstream end of the rehabilitation extent in Lining Section 1. Lanny's PS is only operated for providing wet weather relief to an existing gravity sewer connection to the HRSDS. While the lining is performed, this pump station must be taken out of service and

have a lock out and tag out procedure implemented. This will prevent the pump station from accidentally cycling during dry weather. If wet weather conditions are impending, the lining activities must be suspended, gravity flow in the HRSDS restored, and this pump station must be returned to service.

The most economical style of pump to use is a suction lift pump. Suction lift pumps can be equipped with a variable frequency drive and have a general capacity of 4,000 gpm (8 cfs). Typically, two suction lift pumps can fit into the standard 4-foot diameter manholes of the HRSDS, some modifications may be needed such as removing the cone. The maximum static head for a suction lift pump is around 20 feet. For manholes with a rim-to-invert deeper than 20 feet, options include moving further upstream to a shallower manhole, surcharging the system to increase the HGL to reduce the necessary lift or using submersible pumps. Typical submersible pumps for a bypass pumping application can pump about 5 cfs. Usually only one or two submersible pumps can fit inside a manhole. Larger manholes with the cone removed may fit 3 pumps, otherwise multiple manholes may be required for submersible style bypass pumps.

For the HRSDS, conditions appear to work for one to two suction lift pumps at the main bypass set up. The diameter of the discharge line will be dependent on the operating curves of the selected pumps but most likely will range from 6 to 15 inches.

The overall length of the conceptual discharge lines varies from 800 to 5,600 feet. These bypass routes were developed to completely bypass each lining section. Shorter bypass routes can be developed by dividing lining sections into multiple pieces, each bypassed separately. The lining sections are fed by lateral sewers from the City of Novi which deliver flow to the system that will also need to be bypassed during lining work. This is achieved by using smaller pumps to bypass this flow. Lateral bypass discharge lines can be tied into the main discharge line via a manifold. Multiple lateral bypass discharge lines can be tied into the main discharge line in this way. The information about the City of Novi sewers was obtained from GIS shapefiles provided in September of 2023. Table 8 presents information on the potential pump out manholes on the lateral sewers.

Conceptual bypass routes were determined and are presented in Table 7. Additional details of the Bypass Pumping Analysis, including known tap connections and plan view drawings of the conceptual bypass routes can be found in Appendix K.

Table 7: Summary Information on Conceptual Bypass Routes for Lining Sections

Lining Section	Setup	Bypass of Main HRSDS Interceptor							City of Novi Lateral Sewers with Active Status		City of Novi Lateral Sewers with Unknown Status		Other Total Counts (Main & Laterals)					
		From Manhole	To Manhole	Withdrawal Manhole Depth (ft)	Average Dry Weather Flow Rate (cfs)	PRELIMINARY Bypass Pump Capacity	Approx. Length of Overland Discharge Pipe (ft)	PRELIMINARY Discharge Pipe Diameter (in)	Number of Bypass Setups Required	Approx. Total Length of Overland Discharge Pipe (ft)	Manhole Taps	Blind Taps (a.k.a. Barrel Taps)	Main Road Crossings	Neighborhood Road Crossings	Commercial Driveway Crossings	Residential Driveway Crossings	Bypass Travels Through Existing Storm Culvert	Bypass Travels Under Railroad Bridge
1	Primary	Asset ID 28421	NOT060001	20.7	2.2	4.4	5,300	15	7	1,800	3	7	0	2	1	0	1	0
	Alternate						5,600								7			
2	Primary	NOT060003	NOT091011	15.2	2.5	5.1	4,600	15	6	5,500	5	1	0	1	4	2	0	1
3	Primary	NOT090001	NOT091004	12.4	3.5	7.0	3,100	15	4	1,900	5	0	0	1	6	0	0	1
4	Primary	NOT091006	NOT102008	15.6	3.5	7.0	2,000	15	2	200	0	0	0	0	0	0	1	1
5	Primary	NOT091003	NOT102008	11.0	3.5	7.0	1,100	12	2	200	0	0	1	0	0	0	1	1
	Alternate									1,600			0					2
6	Primary	NOT091002	NOT102003	16.5	4.0	8.0	2,400	15	2	800	4	0	1	0	1	0	1	1
	Alternate									1,600			0					
7	Primary	NOT102005	NOT102002	18.1	4.0	8.0	1,100	12	1	1,000	2	1	0	0	0	0	0	1
8	Primary	NOT102004	NOT104004	13.6	4.0	8.1	3,100	15	0	500	1	0	0	4	0	4	0	0
9	Primary	NOT101003	NOT104004	20.1	4.0	8.1	1,000	12	0	0	0	0	0	3	0	13	0	0
		NOT104002	NOT104004	12.7	0.8	1.5	800	6										

Table 8: Information on Potential Pump Out Locations for Bypass of Lateral City of Novi Sewers

City of Novi Manholes on Lateral Sewer				From Record Drawings			HRSDS Structure that Lateral Connects To	
OCDC Job Number	Asset ID	X Coordinate	Y Coordinate	Invert (ft)	Depth (ft)	Manhole Shaft Diameter (ft)	ID	Type
0629HR	28421	13,359,659.72	361,624.40	902.08	20.72	4	NOT058002	Manhole
0128HR	1616255	13,359,364.53	361,310.29	-	-	-	NOT059005	Manhole
0635HR	13852	13,359,271.60	360,746.27	908.30	17.70	4	NOT059004	Manhole
0290HR	1613598	13,360,444.00	360,689.87	908.00	12.80	-	NOT059002	Manhole
0217HR	1613310	13,361,064.87	359,437.62	904.42	14.58	4	NOT060008	Barrel Tap
0112HR	29226	13,361,298.95	359,313.96	-	-	-	NOT060005	Manhole
0035HR	13843	13,361,698.95	358,927.02	899.17	12.54	4	NOT060003	Manhole
0045HR	1613770	13,362,728.16	358,405.19	-	-	-	NOT085005	Manhole
-	13812	13,362,820.25	357,967.76	-	-	-	NOT085004	Manhole
0102HR	28423	13,363,356.16	357,220.65	-	-	-	NOT085002	Manhole
0075HR	1615542	13,363,897.58	356,717.56	-	-	-	NOT090003	Manhole
0160HR	1614175	13,364,217.33	356,686.00	-	-	-	NOT090002	Manhole
-	1616192	13,364,341.00	356,182.36	-	-	-	NOT091012	Manhole
0161HR	13800	13,364,381.13	355,723.13	-	-	-	NOT091011	Manhole
0121HR	1618243	13,364,981.25	355,819.86	-	-	-	NOT091009	Manhole
0571HR	29238	13,365,599.96	355,007.43	865.70	7.30	-	NOT091007	Manhole
0034HR	28424	13,366,032.00	354,543.41	-	-	-	NOT091004	Manhole
0832HR	28425	13,366,285.55	353,719.05	867.37	4.73	4	NOT091002	Manhole
0075HR	28426	13,366,067.45	353,702.48	-	-	-	NOT091001	Manhole
-	1617105	13,365,995.65	352,307.34	-	-	-	NOT102005	Manhole
0164HR	13763	13,366,457.39	352,157.86	-	-	-	NOT102010	Manhole
0066HR	1614579	13,366,924.00	352,068.50	-	-	-	NOT102003	Manhole

Coordinate Reference System: EPSG:2253 - NAD83 / Michigan South (ft)

6.7 GOVERNMENTAL AGENCY COORDINATION

Multiple governmental agencies will have to be coordinated with during the design and construction phases of the project. Coordination for construction access, construction permits, and easements will be required with the following governmental agencies:

- Oakland County Water Resources Commissioner (OCWRC)
- The Road Commission for Oakland County (RCOC)
- Michigan Department of Environment, Great Lakes, and Energy (EGLE)
- Michigan Department of Natural Resources (Michigan DNR)
- United States Fish and Wildlife Service (USFWS)
- Michigan Department of Transportation (MDOT)
- City of Novi
- Lake State Railway

In addition, coordination with private property owners as well as public and private utility owners will also be necessary. Based on the requirements stipulated by the various agencies/owners, the design should include any restrictions by the governing agencies/owners related to disturbances to existing regulated wetlands, river, floodplain, floodway, Threatened and Endangered Species, roads, railroads, and private land.

6.8 PROJECT DELIVERY

Three delivery options were considered for this project: Design-Bid-Build, Design-Build, and Construction Manager at Risk (CMAR). Generally, CMAR is considered for projects with multiple disciplines, where procurement of long lead items is anticipated, and coordination with various disciplines/subcontractors/vendors is necessary. CMAR was removed from consideration first due to the fact that not many engineering disciplines are involved in the project, and we believe, adding an additional layer to provide coordination will only increase the cost when much of the coordination has been included in the liner study of the BOD phase. Also, there is not a significant "advance" material procurement need other than the liners which a CMAR would be used for.

Design-Build procurement method was also considered and not recommended due to the schedule time of procuring access easements (which is very critical) during a design-build project, whereas the Design-Bid-Build project has the ability to designate and procure "required" easements prior to bidding. Moreover, through the liner study phase of this project, the design team and the Owner has collaborated with various liner manufacturers and "selected" contractors and gained enough understanding of their rehabilitation approach/means and methods. The plan is to incorporate the information collected from the liner study in the design documents, define the boundary conditions to rehabilitate the sewer which allow the contractor to select the most cost-effective rehabilitation solution according to their means and methods to stay competitive. As a result, we recommend that this project is delivered as a Design-Bid-Build.

Several options appear to be comparable with respect to feasibility of sewer rehabilitation. We recommended in the previous sections that multiple lining options be carried forward into design, with a potential for preparing multiple alternatives for bid. This will present both challenges and opportunities related to preliminary engineering and design, packaging bid documents, evaluating

bids, and acquisition of properties and easements; but may allow for greater competition among product manufacturers, thereby lowering construction as well as associated project costs.

There is a fundamental interdependency of flow control in the upstream and downstream portions of the HRSDS system. As such, we do not believe it would be recommended to split the work into more than one contract, without considerable risk of Contractor claims due to interference between contracts. We recognize that options for lining repair vary in terms of constructability, long term performance, and final diameter, with advantages and disadvantages to each. We also recognize that some lining technologies may require additional testing and/or evaluation in order to fully consider the suitability for this project. We believe that such additional testing and/or evaluation should occur as part of the design and may involve pre-approval of material/technology suppliers.

In any case, it is to the advantage of the Owner to obtain as many bids as possible for this project, and as such, we believe there is an advantage to allowing bidding of multiple technologies. Based on discussions with OCWRC representatives and evaluation of presentations from lining product manufacturers, this project is currently following a traditional design-bid-build delivery approach. The bid package will address recommended liners along with bypass options and access considerations associated with the rehabilitation of the HRSDS.

Evaluation of the bids themselves may present a challenge when multiple bid alternatives are considered. Each of the lining options being considered may result in a different finished diameter of the interceptor, and the Owner may wish to consider a bid that results in a larger finished diameter, even at a higher bid price. Similarly, the Owner may wish to select a bid that utilizes a more proven technology and construction method or requires the least amount of disturbance or third-party impacts, even if that bid is not the lowest responsive/qualified one. We understand based on our discussions with the Owner that the Owner will need the latitude to make these evaluations, in its best interest and following the requirements of the General Conditions.

In the bid proposal, a combination of Lump Sum and Unit Price Items will be arranged to address the unique requirements of the system. The structure of the proposal will be developed to encourage maximum participation by "pre-selected" lining manufacturers for each sewer rehabilitation reach, while providing options for the Project Owner for final decision making following the General Conditions of the project. Through this process, it is envisioned that each participating liner manufacturer have opportunities to increase its participation by selecting the most cost-effective solution for each liner reach (number of access shafts, bypass requirements, etc.) The fine details will be determined during the preparation of Issue for Bid contract documents.

7.0 RISK REGISTER

A pre-construction risk register has been developed for this project. The intent of developing a risk register during the preliminary design phase of the project is to identify potential project risks early so that mitigation efforts can take place throughout the design phase. The risk register prepared by NTH for this project identifies a variety of technical design and project execution risks that have potential impacts to project cost, schedule, environment, and safety. General categories of identified risks include access relates risks, product related risks, weather/flow control risks, and project cost related risks. Individually identified risks, mitigation treatment plans, potential impacts and risk rankings are provided in the Risk Register described in Table 9 below.

Table 9: Basis of Design Risk Register

OCWRC - HRSDS Novi Trunk Extension No. 1 Sewer Rehabilitation Project

Basis of Design - Risk Register

Risk No.	Category	Status	Risk Description	Treatment Type to Modify Risks (Avoid, Transfer, Mitigate, Accept)	Risk Treatment Plan	Action Items		Impact Basis	Before Treatment			After Treatment			Trend	Task Completed (Date)
									Most Likely			Most Likely				
	Threat/ Opportunity					Description (Task Lead)	Status (Due Date)		Impact Category	Probability Category	Risk Ranking	Impact Category	Probability Category	Risk Ranking		
001	T	Active	Funding availability	Mitigate	OCWRC to mitigate	OCWRC	1/29/2024	Cost/ Schedule	High	Medium	Medium	Low	Low	Low		
002	T	Active	Cost escalation - materials and installation costs	Mitigate	Increase competition - multiple pre-approved products, adjust bidding/bid package strategies	NTH	4/10/2024	Cost	Medium	Medium	Medium	Low	Low	Low		
003	T	Active	Limited prospective bidders	Mitigate	Actively reachout to prospective bidders, advertise both locally and nationally	NTH	4/10/2024	Cost	Medium	Medium	Medium	Low	Low	Low		
004	T	Active	Dewatering for access shafts affecting nearby facilities	Mitigate	Identify existing wells in area, study the potential radius of influence, include contingency allowance in bid proposal. Request water tap information from City of Novi to help identify existing wells (both residential and commercial)	NTH	3/11/2024	Cost	Medium	Medium	Medium	Medium	Low	Medium	→	
005	T	Active	Dewatering "bottling" permit requirement	Mitigate	Pump testing to understand rate of discharge, apply for permits early in construction phase	NTH	3/11/2024	Schedule	Medium	Medium	Medium	Medium	Low	Medium	→	
006	T	Active	Easement and access negotiations delay	Mitigate	Begin easement identification early in design phase and begin negotiations during design	NTH/OCWRC	4/24/2024	Cost/ Schedule	High	High	High	Medium	Medium	Medium	→	
007	T	Active	Easement costs - potential for unused easements depending on number of shaft sites the contractor	Mitigate	Use retainer/token easement agreement approach.	OCWRC	4/24/2024	Cost	Medium	Medium	Medium	Medium	Low	Medium	→	
008	T	Active	Railroad ROW constraints	Mitigate	Communication early and often	NTH	4/10/2024	Schedule	High	High	High	High	Medium	Medium		
009	T	Active	Bypass pumping failure	Mitigate	24/7 pump watch requirement in contract, redundant equipment requirement, daily inspections	ASI/NTH	4/24/2024	Environmental	Medium	Medium	Medium	Medium	Low	Medium	→	
009.1	T	Active	Odor and noise requirements for bypass pumps	Mitigate	Include language in the contract documents to have the relief valves/generators away from residential areas	ASI/NTH	4/24/2024	Environmental	Medium	Medium	Medium	Medium	Low	Medium	→	
010	T	Active	Slip-lining through alignment changes (vertical and horizontal)	Mitigate	Communication with vendors and potential contractors to troubleshoot during design phase, right sizing of liner diameter	NTH	3/11/2024	Cost/ Schedule	High	Medium	Medium	High	Low	Medium	→	
011	T	Active	Slip-liner getting stuck under road, railroad, river, alignment changes	Mitigate	Require mandral testing before beginning installation, right sizing of liner diameter	NTH	4/10/2024	Cost/ Schedule	High	Medium	Medium	High	Low	Medium	→	
012	T	Active	Short joint slip-lining for manhole to manhole installations. Not the standard practice for slip-lining. Limited working space.	Mitigate	Communication with vendors and potential contractors to troubleshoot during design phase	NTH	4/10/2024	Schedule	High	Medium	Medium	High	Low	Medium	→	
013	T	Active	Material lead-time schedule delays. Products shipped from overseas, damage during shipping	Mitigate	Pre-approved products list include multiple products for Contractors to consider and price. Push for early submittal of liner materials to expedite ordering of material	NTH	4/10/2024	Schedule	Medium	Medium	Medium	Medium	Low	Medium	→	
014	T	Active	Health and Safety. Work includes confined space and live sewer work.	Accept	Specifications require Contractor submit and carry-out appropriate health and safety plan. JSA, confined space permits, ventilation, flow monitoring. Include "Lock Out/Tag Out" procedures for City of Novi Pump Station.	NTH	4/10/2024	Safety	Medium	Low	Medium	Low	Low	Low		
015	T	Active	Wet weather schedule delays. Unpredictable weather. Wet weather events can impact bypass pumping operations and liner installation in live sewer.	Accept	Define wet weather schedule considerations within the contract. Track wet weather days for potential claim negotation. Define flow control management responsibilities in the contract. Identify who is responsible for flow control monitoring (Owner or Contractor)	NTH/OCWRC	4/10/2024	Schedule	Medium	High	Medium	Medium	Medium	Medium	→	
016	T	Active	Product warranty or availability of extended warranty. Potentially for not honoring warranty	Mitigate	Pre-approve product manufacturers with a strong history. Avoid unproven products/product manufacturers. Collect warranty agreements early during submittal process. Add language to include warranty inspection (by the Contractor) prior to warranty expiration period.	NTH	4/10/2024	Reputation	Medium	Medium	Medium	Medium	Medium	Medium	→	
017	T	Active	Product manufacturer design risks. Faulty design or experimental products	Mitigate	"Pre-approve product manufacturers with a strong history. Avoid unproven products/product manufacturers.	NTH	4/10/2024	Reputation	Medium	Medium	Medium	Medium	Medium	Medium	→	
018	T	Active	River crossings for access roads and bypass pumping	Mitigate	Coordination and communication with EGLE and City of Novi	NTH	3/11/2024	Schedule	High	Medium	Medium	Medium	Medium	Medium	→	
019	T	Active	Styrene use/mitigation in CIPP products	Mitigate	Include language in the contract documents	NTH	4/24/2024	Cost	Medium	Medium	Medium	Low	Low	Low		
020	T	Active	Schedule considerations based on T&E timelines	Mitigate	Include language in the contract documents defining the schedule contraints/limitations"	NTH/Barr/AEW	4/24/2024	Schedule	Medium	Medium	Medium	Medium	Medium	Medium	→	
021	T	Active	Identify manholes that were poured with excess concrete during construction and identify them in design	Mitigate	Identify and include language in the contract drawings to identify those manholes to avoid change conditions claim	NTH/AEW	4/24/2024	Cost/ Schedule	Medium	Medium	Medium	Medium	Medium	Medium	→	

Notes:

Treatment for Threat: Avoid, Mitigate, Accept, or Transfer

Treatment for Opportunities: Exploit, Share, Enhance, or Accept

For Opportunities: Cost and schedule impacts need to be entered as negative values

HRSDS_Risk Register_Final

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8.0 ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS

As part of our basis-of-design evaluations, we considered a number of sources to develop planning-level cost estimates for the various options under consideration. For our evaluation of both cost and schedule, we contacted (and or met with) multiple manufacturers, suppliers, and contractors that are experienced in the various lining rehabilitation methods discussed earlier in this report. Discussions with these manufacturers, suppliers, and contractors were supplemented with the experience of the design team members in most of the technologies under consideration.

Based on our preliminary evaluation, the Engineer's Opinion of Probable Construction Cost estimate for the full rehabilitation scope to be approximately $16,600,000 – $20,500,000, including a 20 percent contingency. The contingency allowance is added to account for unforeseen conditions as well as changes in scope and market conditions (inflation rates, fluctuation in material prices etc.) during bid time, which is scheduled to occur in the summer of 2024.

The Engineer's Opinion of Probable Construction Cost was developed to include the various lining options for each of the eight (8) designated lining sections. The lowest-cost lining options and the highest-cost lining options were then tabulated for each lining section, along with general conditions items, to provide the estimated construction cost range as stated above. See the attached spreadsheet in Appendix L for the full breakdown of our Conceptual Cost Estimate along with the assumptions used in calculating this data.

It is important to note that a basis-of-design level cost opinion is a preliminary estimate meant to facilitate budgetary and feasibility determinations, and as the project progresses through detailed design and development phases, this cost estimate will be refined and updated to match the bid scope.

9.0 ENGINEER'S OPINION OF PROBABLE CONSTRUCTION SCHEDULE

At this time, and on the basis of the design discussed herein, the conceptual construction duration for the HRSDS Rehabilitation Project is estimated to be approximately 18 months. The conceptual schedule is based on a linear progression of construction activities starting from Section 1 through Section 8 (upstream to downstream in the system). The development of this basis-of-design-level schedule assumes a deployment of one crew working from one site to the next, wherein reality, the Contractor may likely employ multiple crews working simultaneously at multiple lining sections which would potentially reduce the overall duration of construction. The schedule also assumes that the entire scope of work is performed under a single Contract rather than multiple. A four-day work week was also assumed when developing the conceptual schedule. This is a standard MDOT format for schedule estimation and was included in order to incorporate wet-weather days, holidays, and other miscellaneous system days that would otherwise impact daily work activities.

As discussed earlier, Threatened and Endangered species considerations will also impact the construction schedule. Based on the findings of Barr's T&E desktop review, no impacts to construction schedule are anticipated estimated if work occurs between November 1st and March 31st. However, if work is implemented between April 1st and October 31st, additional construction schedule delays are anticipated requirements, as a result of the requirements to protect various threatened and endangered species documented in proximity to the project area. have the potential to inflate the schedule. These requirements may include performing additional environmental

inspections, installing wildlife safe fencing, and potential consultations with USFWS and MDNR if tree removal is required prior to allowing the initiation of construction operations. Additional schedule impacts artificial interruptions in the schedule to consider include extreme weather impacts, temporary river bridge crossings, wetland restrictions, and other similar restrictions that may require the Contractor to move to another area and then return to impacted areas when available. A graphical representation of the schedule in the form of a Gantt chart is included in Appendix L.

Note that this conceptual construction schedule and activity details/durations will be further detailed and expanded during the design phase of the project when additional project construction tasks and activities are further defined.

10.0 CONCLUSIONS AND RECOMMENDATIONS

Based on our understanding of the HRSDS, and evaluation of various rehabilitation options, the following conclusions and recommendations are drawn for consideration in the design phase of the project:

- The Condition Assessment of the HRSDS Novi Trunk Extension No. 1 revealed that a majority of the reaches have defects which are of a long-term concern for the structural integrity of the sewer. As such, structural rehabilitation of the sewer is recommended for the entire alignment of approximately 16,700 feet from manhole MH-45 (NOT 058002) to MH-0 (NOT 104003).
- We compared installation of new pipe segments or pipe bursting technique to replace the existing sewer against various rehabilitation options and concluded that replacement option will be costly and disruptive. Therefore, rehabilitation option is recommended for design consideration over sewer replacement. To ensure that the rehabilitation provides the serviceable life expected by the OCWRC, the design and construction of the lining shall consider the following, but not limited to:
    - The host pipe shall be assumed to be fully deteriorated, and rehabilitation options need to withstand full overburden pressure, including hydrostatic head.
    - Minimum 50-year life span for the rehabilitated pipe.
    - The design of the liner rehabilitation shall follow ASTM, ACI, AWWA, ISO, and other applicable design standards, per the liner manufacturer's specifications.
    - Contract documents shall include requirement for preventing floatation during annulus grouting operations.
    - Contract documents shall include the requirement to seal liner ends for CIPP and other tight-fitting liners.
    - Contract documents shall include requirements for surface preparation and leak sealing meeting the manufacturer's recommendations.
- Based on the rehabilitation needs, we identified a total of 12 rehabilitation liner products that appear to be appropriate for lining the 36-inch concrete sewer. The final lining products

chosen for installation will be based on our evaluation and recommendation during the design phase of the project as well as the bid process detailed in the project delivery section of this document.

- Microbially induced corrosion is present throughout the HRSDS. It is most severe in areas where turbulent flows are present such as immediately downstream of manhole MH-44A (NOT 058001). Materials used in lining rehabilitation must be resistant to exposures to chemical reagents that may be found in the sewer including but not limited to raw sewage, hydrogen sulfide, sulfuric acid (byproduct of thiobaccillus bacteria causing MIC), and petroleum products. The materials must also resist degradation including but not limited to shrinkage, elongation, swelling, blistering, softening, wrinkling, brittleness, peeling, bulging, delamination, cracking, and scouring.

- The principal cause of the historic sewer failures has been piping of soil fines through cracks and joints of reinforced concrete pipes at locations of running and gushing leaks. Evidence of these voids from historical running and gushing infiltrations along the HRSDS alignment was observed during the geotechnical exploration near 10 Mile Road. Given the historical failure mechanism associated with running and gushing leaks, and the tendency of leaks to migrate when the drainage path is sealed, it would be prudent for the liner system selected to prevent the leaks once the liner is installed (i.e., watertight liner). With ground surface to invert depths ranging from 11 to 30 feet, it is reasonable to expect ground water pressures of 5 to 13 psi. These pressures need to be considered when designing liner systems.

- It is likely that the flow in the HRSDS contains aggregates and other particles that are abrasive. Accordingly, the materials used for lining rehabilitation should be abrasion resistant. The source of the aggregates is likely from storm runoff at manholes, migration from infiltration, and loose aggregates resulting from the effects of MIC on the concrete walls, or other sources. Abrasion resistance testing to establish the durability of the selected material should be carried out in accordance with the ASTM Standard G195 (Standard Guide for Conducting Wear Tests Using a Rotary Platform, Double-Head Abraser). The resistance to scour should also be considered in final liner selection.

- Based on hydraulic studies of the system, the minimum sizes of pipe required for a 25-Year, 24-Hour design event ranges from 24 inches to 26 inches in internal diameter (finished diameter). However, it is desired to maintain the finished liner diameter to as large as reasonably possible to allow for future rehabilitation of the pipe that may require further reductions beyond those contemplated currently. As such, the cross-sectional reduction of the sewer after rehabilitation shall be optimized during the design phase, following additional discussions with liner manufacturers.

- Bypass pumping will be required for uninterrupted sewage flow during rehabilitation that require no flow in the sewer, including bypass of the laterals. The diameter of the discharge line will be dependent on the operating curves of the selected pumps but most likely will range from 6 to 15 inches. We recommend considering the existing varying surface terrain, the existence of regulated woodlands/wetlands, minimizing crossing of roads, railroads, and river, as well as the Federal and State listed threatened and endangered species along the bypass route.

- In the event that a slip-lining methodology is selected for rehabilitation, the existing manholes are not large enough for implementing this technology. Therefore, individual insertion and recovery "pits", or TERS, will be required. Based on review of the sewer alignment, there are several reaches of "straight" alignment with multiple manholes along each reach. We recommend including up to eight (8) access pits or shafts at "select" locations to allow for lining long reaches of pipe from single access location to reduce setup time. Since there is uncertainty in the number and location of access shafts required for the various lining options, we recommend that options for easements be negotiated to allow the Owner to exercise the option only if the easement is needed. Furthermore, we recommend obtaining "permanent" easement(s) from public right-of- way to the access shaft locations and maintain an access path for future sewer access and maintenance.

- The available historic explorations provided some data such as the types of soils and some limited laboratory testing, but the data is not site-specific, and is not sufficient for a complete understanding of the subsurface conditions necessary for design of the access pits/shafts. During design phase, gap analysis on existing subsurface data and required supplemental geotechnical exploration should be performed based on the access shaft excavation requirements. Also, our preliminary understanding of anticipated soil and groundwater conditions suggests that some level of dewatering effort will be required at localized excavations to access the sewer. Moreover, considerations for dewatering methodologies, permits, impact on private wells (if any), and related issues should be carefully considered and addressed during the design.

- The initial environmental corridor study identified several reaches where potential environmental concerns exist along or adjacent to the corridor. For the sites where near-surface soils will be disturbed through open cut excavations, a subsurface environmental investigation is recommended. The results of the investigation will identify the severity of contamination, if any, and assist in preparing construction due care guidelines, including soil management and disposal procedures, and recommendations for project contractors to develop appropriate health and safety plans prior to initiating subsurface construction work.

- At the above access pit/shaft locations, we recommend installing a larger diameter manhole (greater than 4 feet) for ease of future access. Also, we recommend modifying any existing manholes recommended for access during construction by replacing the cone section with a circular 4-foot diameter riser with flat top configuration for future access and maintenance.

- Considering the alignment of the sewer running through various commercial, residential, and industrial developments, temporary and permanent construction easements may be required. The acquisition of construction easements for laydown areas, bypass piping, as well as access roads will require advance planning and potentially long lead times to secure legal descriptions and agreements. The uncertainty in the number and location of access pits/shafts and various options for bypass piping routes that will be required for the various options presents a challenge in obtaining the needed property and easement agreements. In consideration of the above, it will likely be necessary to move forward with easement acquisition at all of the potential shaft locations and other access manhole locations. We recommend that options for easements be negotiated to allow the Owner to exercise the option only if the easement is needed. This will depend on the final contractor selection and

method of rehabilitation. Although some of the options for easements may not be exercised, we believe that the overall reduction in the bid amounts from the competition created by allowing different lining technologies will more than offset the cost of potentially unused easements. In addition, and in consideration of the varying access and bypass locations, complex neighborhoods and a well-established community base, this project should include an informative advance notice of the construction program to advise the "affected" community of the project scope.

- Multiple governmental agencies and private parties will have to be coordinated during the design and construction phases of the project. This is critical to avoid construction delays and project costs. Coordination for construction access, construction permits, consultation, and/or easements may be required. Based on the requirements stipulated by the various agencies/owners, the design shall include any restrictions by the governing agencies/owners related to disturbances to existing regulated wetlands, river, floodplain, floodway, Threatened and Endangered Species, roads, railroads and private land.
- Based on presentations by the various lining manufacturers, the host pipe will need to be properly prepared prior to lining. As such, we recommend that the construction contract include as needed sewer cleaning to remove accumulated deposits.
- To address the sewer infiltration, we recommend that the construction contract include as needed chemical and/or cementitious grouting to address gushing and running sewer infiltrations. Moreover, we recommend that the construction contract include as needed localized concrete sewer and manhole repairs to address localized concrete spalling if any.
- Develop a bid proposal to encourage maximum participation by "pre-selecting" lining manufacturers for each sewer rehabilitation reach, while providing options for the Project Owner for final decision making. Through this process, each participating liner manufacturer and contractor will have opportunities to increase their participation by selecting/deciding the most cost-effective solution (number of access shafts, bypass requirements, etc.) for each liner reach according to their means and methods.
- As part of the design phase, develop strategies to reduce or eliminate the project risks identified in the BOD. This may include creating contingency plans, including allowances or pertinent design detail(s)/specification(s) into the contraction contract documents, which help to minimize disruptions and unexpected project costs.
- Based on our preliminary evaluation, the Engineer's Opinion of Probable Construction Cost estimate for the full rehabilitation scope to be approximately $16,600,000 – $20,500,000 and may take approximately 18 months to complete from notice to proceed.

11.0 REFERENCE DOCUMENTS

The following documents were used as references to develop this report:

1) Novi Trunk Extension No. 1, Contract Nos. 1, 2, and 3 – Initial Evaluation Report by NTH, dated August 15, 2022

2) Various Manufacturer Presentations, held at NTH and OCWRC Offices and/or virtually, August to September 2023 (*Electronic Format)*