TAG/R ONLINE

TRENCHLESS ASSESSMENT GUIDE

User's Manual

Version 3.0 - February 2009

Developed for:

The National Utility Contractors Association

And

The National Association of Sewer Service Companies

By:

The Trenchless Technology Center
Louisiana Tech University

Credits: John C. Matthews, Dr. Zhenyang Duan, Joseph Berchmans and Prof. Erez N. Allouche

TTC DISCLAIMER

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The suggestions, procedures, and precautions set forth in this manual and on this program are a compilation and explanation of methods and equipment successfully used by contractors to install underground utilities. These suggestions, procedures, and precautions should not be considered as an infallible method of installing underground utilities. Accordingly, there is no guarantee that the methods and procedures will be successful in all applications. While the authors have done their best to ensure that the information in this manual is accurate; no liability or responsibility of any kind is accepted by the authors, the National Utility Contractors Association, or the Trenchless Technology Committee.

NASSCO DISCLAIMER

The decision, by an Engineer, Designer or Municipal Official (decision makers) of how to accomplish the renewal of a deteriorated buried pipe, in an urban environment, must be based on tangible parameters. These parameters can then be assembled and inserted in a computer software program to create a tool that simplifies this decision process.

NASSCO and the Trenchless Technology Center (TTC) of Louisiana Tech have developed this comprehensive, yet straightforward and user friendly interactive software for the evaluation of alternative renewal methods. These methods can then be employed in the rehabilitation of gravity pipes, pressure pipes, laterals and manholes.

The software will emphasize simplicity and practicality, and limits input data to those readily available to utility and municipal engineers at the design stage of a renewal project. Based on the specific characteristics of the problem(s) facing the decision-maker, the software performs a preliminary screening, eliminating technologies unlikely to meet the project's requirements. A technical evaluation is then undertaken, during which the technical capabilities of the various technologies identified in the first step are compared with the project's requirements.

The TAG-R program takes into account extensive performance data for a number of technologies and sub-technologies for access point to access point pipe renewal, a number of spot repair technologies and manhole renewal methods commonly used for pipe renewal projects.

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A. INTRODUCTION

A.1. BACKGROUND

The decision of how to accomplish the installation or repair of a buried pipe in an urban environment involves tangible and intangible parameters. To assist with that decision, NUCA's Trenchless Technology Committee commissioned the Trenchless Technology Center (TTC) to develop a straightforward and easy to use interactive software program for the evaluation of alternative construction methods that can be employed in the installation or replacement of buried pipes and conduits. The program, titled TAG (Trenchless Assessment Guide), was designed as a stand-alone software to assist municipal and utility engineers in evaluating the technical feasibility of various traditional new installation open cut, new installation trenchless construction and inline replacement methods for a specific project, and is intended to be a companion to NUCA's Trenchless Construction and Rehabilitation Methods Manual (4th Edition). Trenchless rehabilitation methods were not considered during the technical evaluation of a project by Version 1 of the software, but they were included in Version 2 of the software developed in conjunction with NASSCO called TAG-R. TAG Online combines NUCA's Version 1 with NASSCO's Version 2 to create the complete evaluation software.

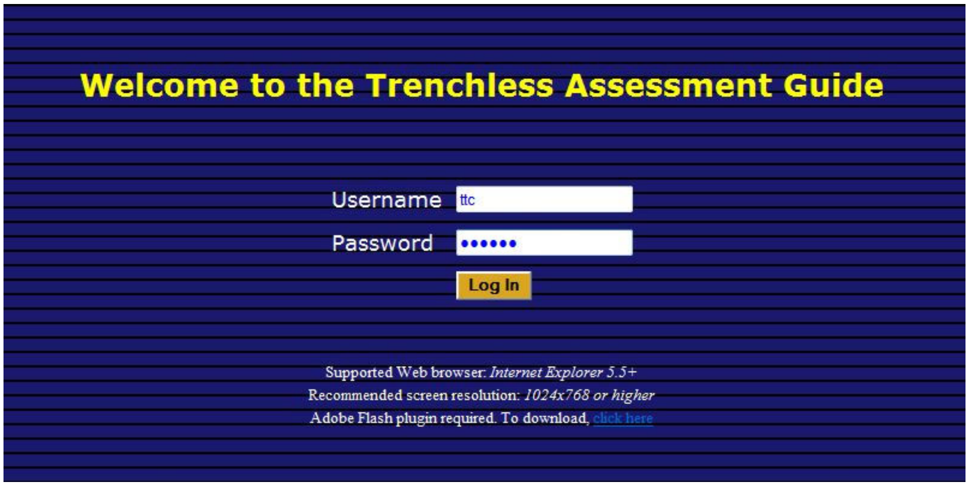
TAG/R takes into account extensive performance data for more than 70 construction methods commonly used in utility type projects. The software emphasizes simplicity and practicality, and limits input data to that which is readily available to utility engineers at the design stage of the project. Based on the characteristics of the problem(s) facing the decision-maker, the software performs a preliminary screening aimed at eliminating technologies unlikely to meet the project's technical requirements. A technical evaluation is then undertaken during which the technical capabilities of various technologies identified in the first step are compared with the project's attributes. Next, a risk analysis is performed, if a new alignment or inline replacement is considered, based on the characteristics of the project's environment and anticipated soil conditions. Finally, the recommendations of the program are shown with their respective risk score's if applicable.

A.2. SYSTEM REQUIREMENTS

TAG Online is compatible with Microsoft® Windows® Internet Explorer.

A.3. ACCESS

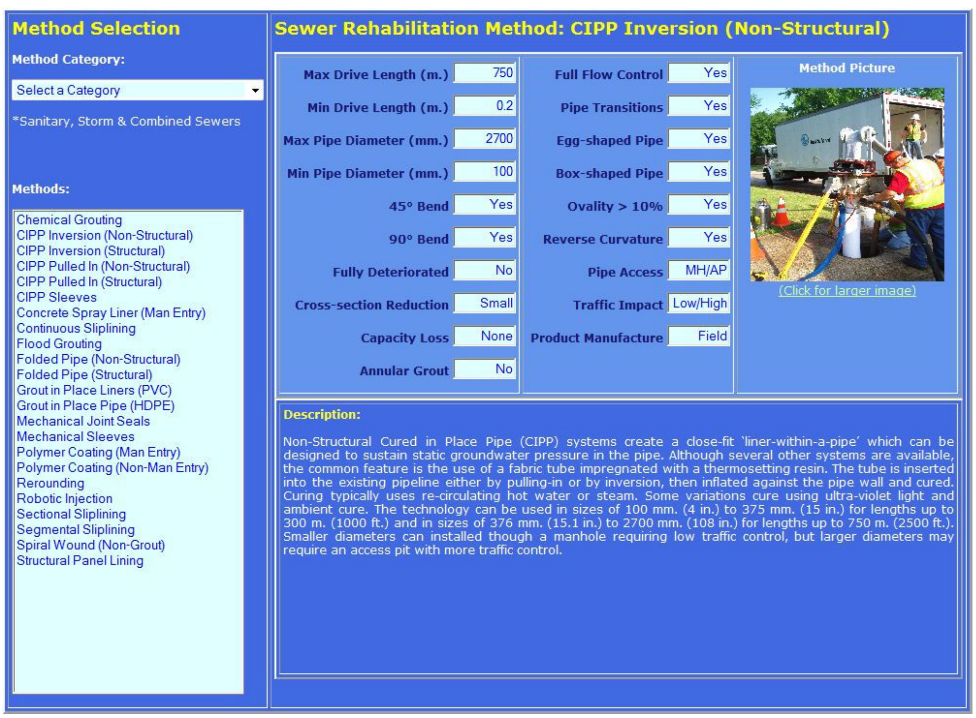
The web address to access TAG Online is <http://138.47.78.37/rtag/>. The user is asked to enter a Username and Password. The temporary login information is given here and is followed by screen shot of the login page: **Username**: ttc **Password**: ttc123



B. CONSTRUCTION METHOD DATABASE

B.1. STRUCTURE

The relational method databases contain a plethora of information about each method. The general information section includes a detailed description and a representative color picture. The method's technical capabilities include maximum and minimum pipe diameters, maximum and minimum drive lengths, etc. Other technical information embedded in the database is the method's level of compatibility with ten common types of soil (defined in Appendix E.1); compatibility with various common pipe materials; environmental impact factor; required extent of excavation; groundwater table classification; alignment accuracy; profile accuracy; ability to navigate bends; ability to rehabilitate different deterioration levels; etc.. All of the construction parameters are defined in Appendix E.1.



C. TUTORIAL

C.1. CASE STUDY 1

This case history was taken from the J. Edward Drain Interceptor Project in Westfield, Indiana. Due to the rapid growth of the town, which is located about 24 km. (15 m.) north of Indianapolis; a new sewer system was required to satisfy the increasing volume of wastewater. This particular segment considered was constructed in 2004 on a 175 m. (575 ft.) stretch of 600 mm. (24 in.) vitrified clay pipe. Relevant input parameters are summarized below.

J. Edward Drain Interceptor - Information Summary

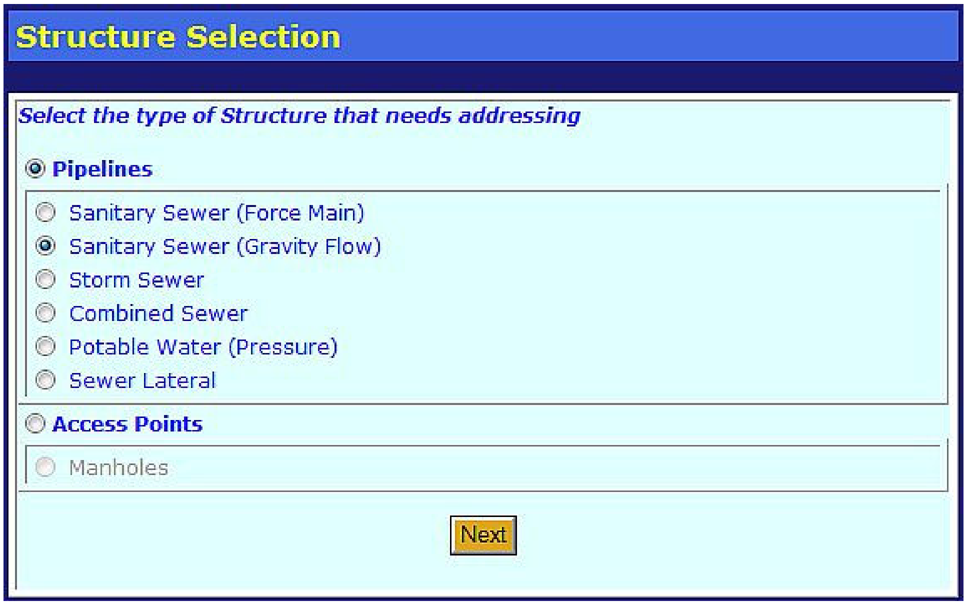
Length	175 m. (575 ft.)
Depth	6 m. (20 ft.)
GWT Depth	4.5 m. (15 ft.)
Host Pipe Diameter	N/A*
Host Pipe Material	N/A*
New Pipe Diameter	600 mm. (24 in.)
New Pipe Material	VCP
Alignment Accuracy	4 (High)
Profile Accuracy	4 (High)
Soil Type #1	Medium Sand (40%)
Soil Type #2	Soft Clay (35%)
Soil Type #3	Gravel (25%)
Excessive Sagging	N/A*
Pipe Upsize > 2.5	N/A*
Extent of Excavation	Access/Receiving Pits Only
Site Accessibility	Limited Accessibility (Golf Course)

*N/A – Not Applicable

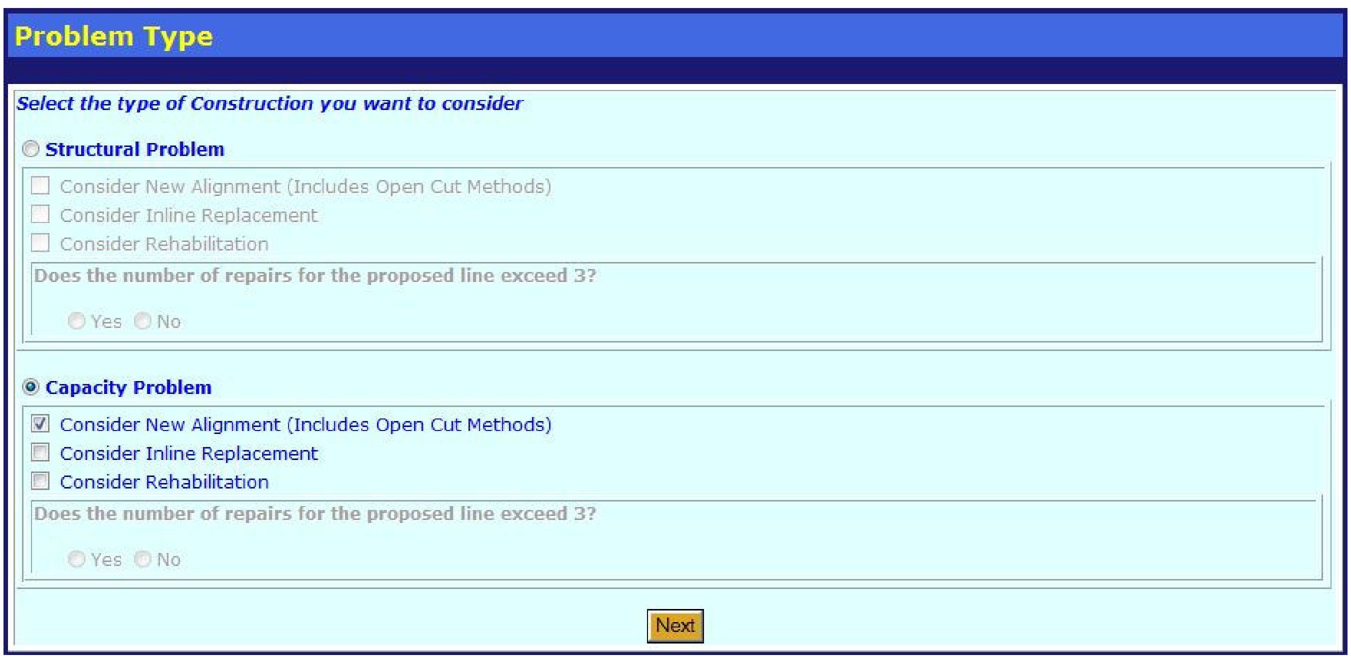
TAG consists of 2 primary phases, a technical evaluation and a risk analysis. The verification exercise begins with the extraction of the relevant technical information from the design documents for use as input data. Rehabilitation methods were not considered due to the fact that more capacity was needed.

C.1.1. Problem Selection

Begin by clicking on **Technical Evaluation** at the top of the main page which leads to the Structure Selection page. Select the type of structure that needs addressing, which in Case #1 is **Pipelines** and **Sanitary Sewer (Gravity Flow)** and then click **Next**.



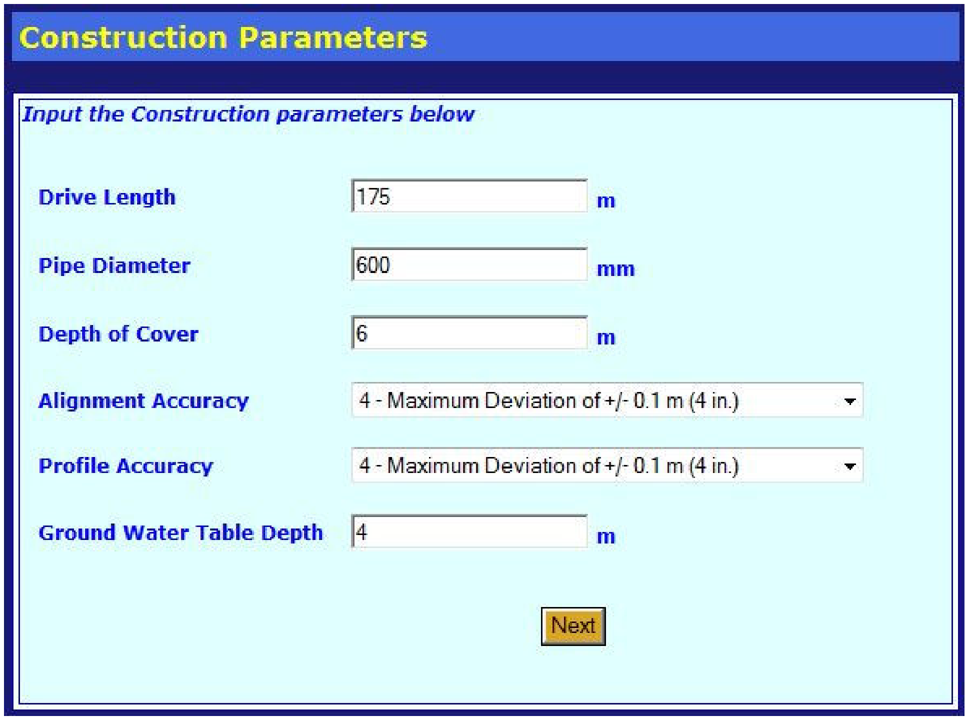
Since the pipe is lacking capacity select **Capacity Problem**. Then select **Consider New Alignment (Includes Open Cut Methods)** and then click **Next**.



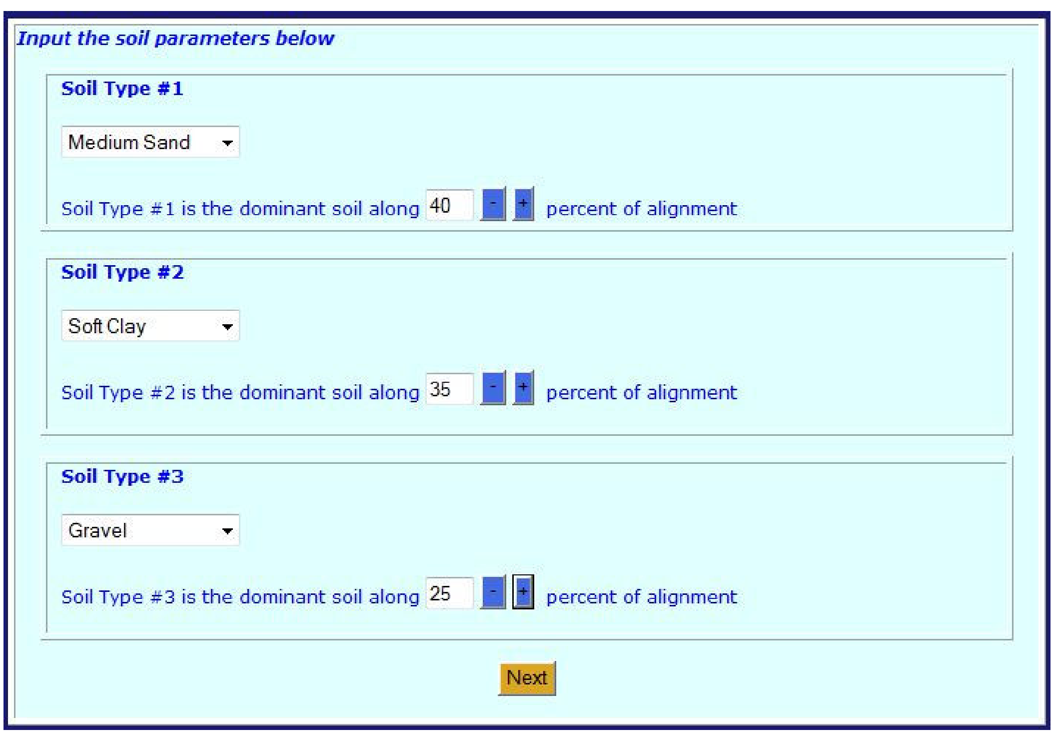
C.1.2. Project Input

Based on the definition of the problem the software will only be considering New Alignment methods, but trenchless methods for Inline Replacement and Rehabilitation methods can be added to the evaluation by checking their respective check boxes. Next, the user is asked to input the following installation parameters: **Drive Length** = 175 m, new **Pipe Diameter** = 600 mm, **Depth of Cover** = 6 m, **Alignment Accuracy** = 4 (High; defined in Section D.1.), **Profile Accuracy** = 4 (High; defined in

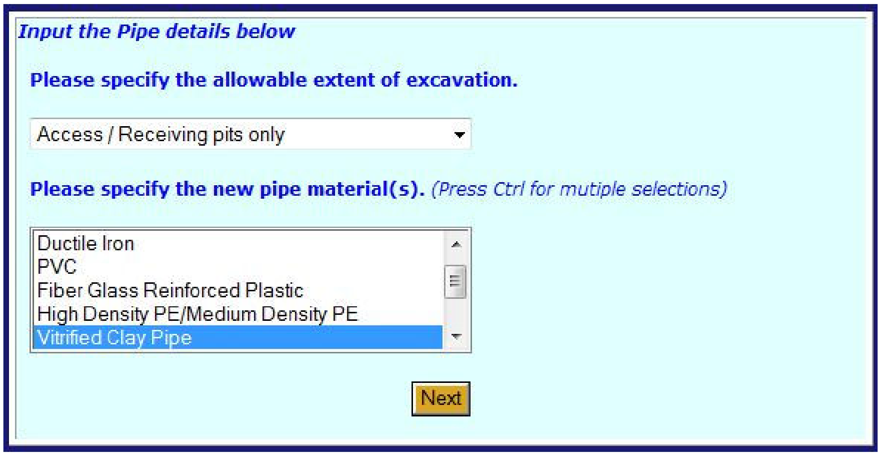
Section D.1.), and **Ground Water Table Depth** = 4 m. Input these values into the **Construction Parameters** page and then click the **Next** tab.



The three dominant soils along the alignment are **Medium Sand** (40%), **Soft Clay** (35%) and **Gravel** (25%). Input these values into the **Soil Parameters** page by first selecting the three soils and then adjusting their respective percentages. Then click **Next**.

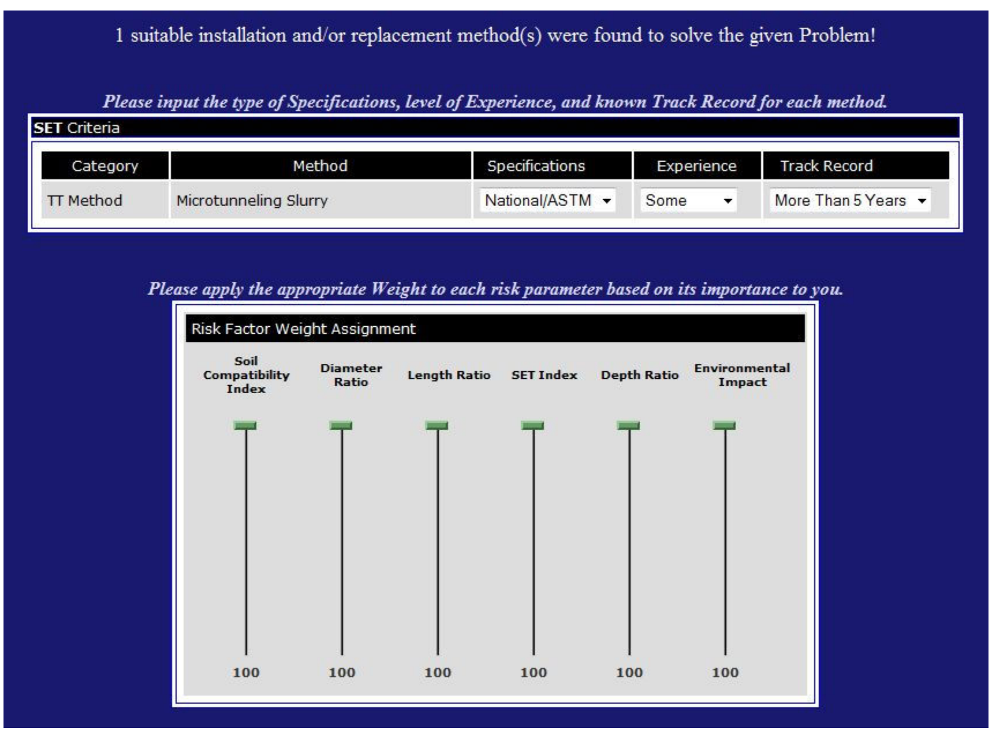


For the **Pipe Installation Details** specify the **Allowable Extent of Excavation** as **Access/Receiving Pits Only**, since the project is on a golf course and select **Vitrified Clay Pipe** as the pipe material and click **Next** to go to the Risk Analysis.

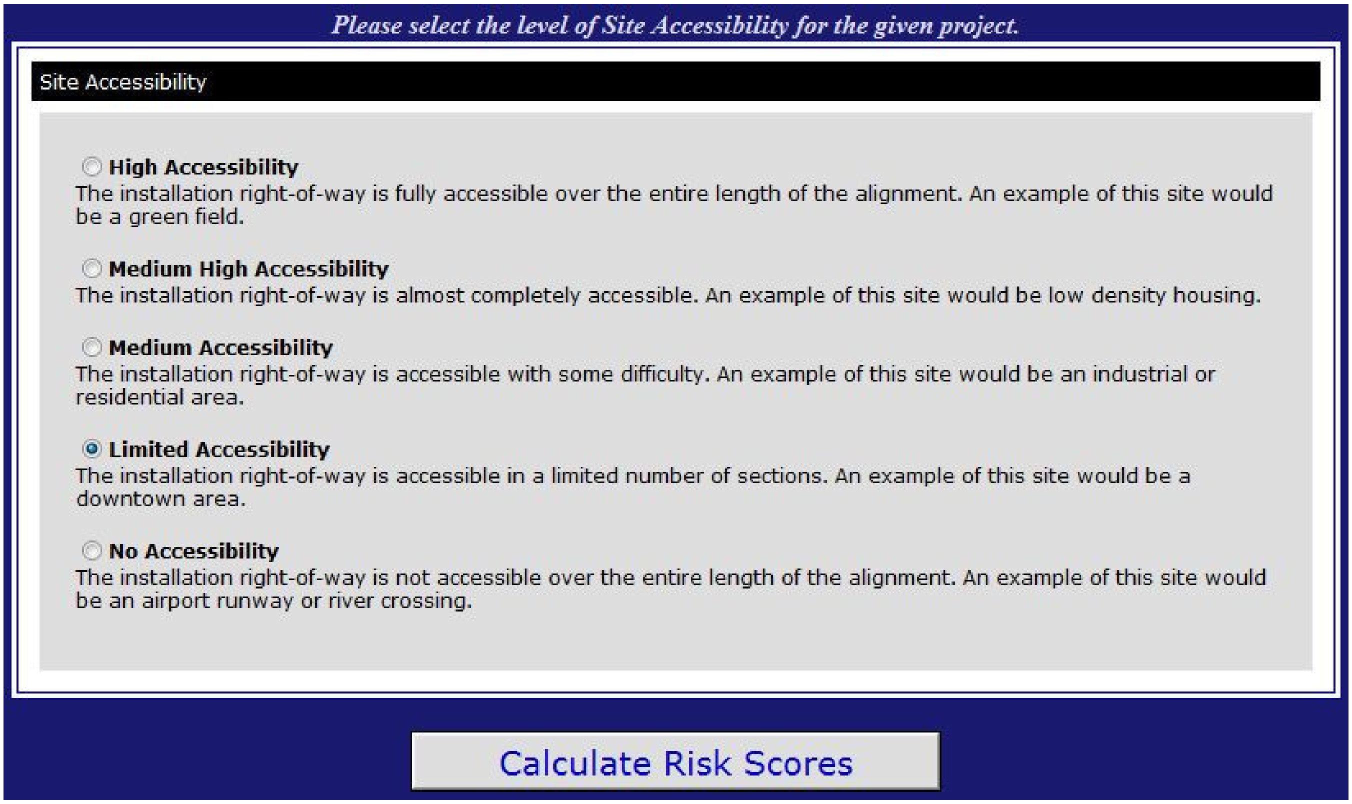


C.1.3. Risk Analysis

Although only one method was found to be technically viable the risk analysis will still assign a level of risk relative to the project data. To begin the risk analysis, input the **SET Criteria** by selecting one option from each of the three categories based on your experience: **Specifications** availability (**National/ASTM** for Microtunneling Slurry), owner's **Experience** (**Some** for Microtunneling Slurry), and method **Track Record** (**More than 5 Years** for Microtunneling Slurry). After selecting one option from each category go to the **Weight Adjustment** section and assign a weight to each of the six risk factors based on their importance in relation to the project under consideration.

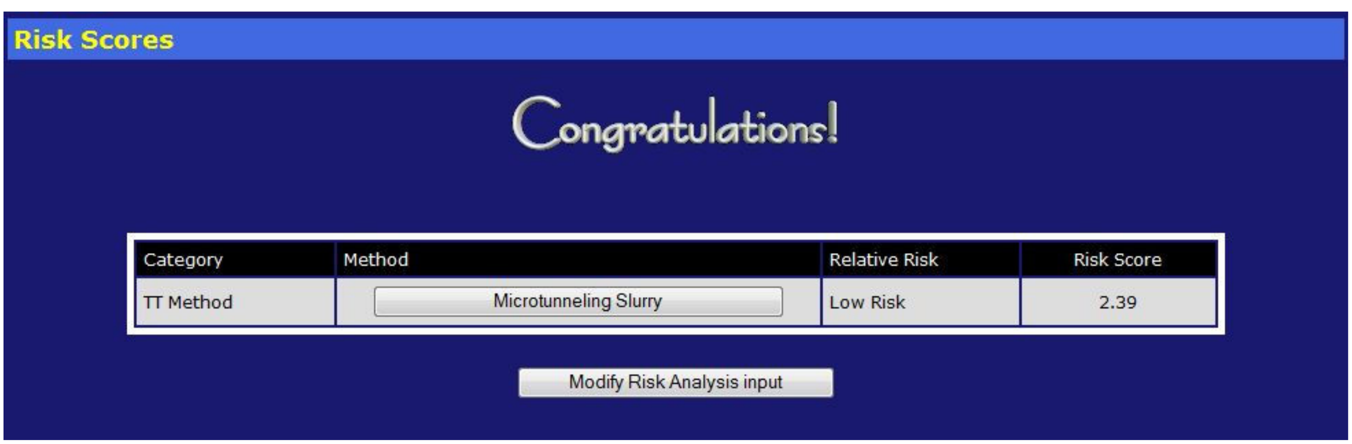


You may choose to leave the weights at their default values, with each risk factor having an equal weight. Now, select the **Site Accessibility** from one of the five options shown (**Limited Accessibility** in this case) and then click **Calculate Risk Scores**.



C.1.4. Results

The results of the complete analysis are displayed on the **Risk Scores** page which contains all technically viable methods, their respective values, and risk classifications.

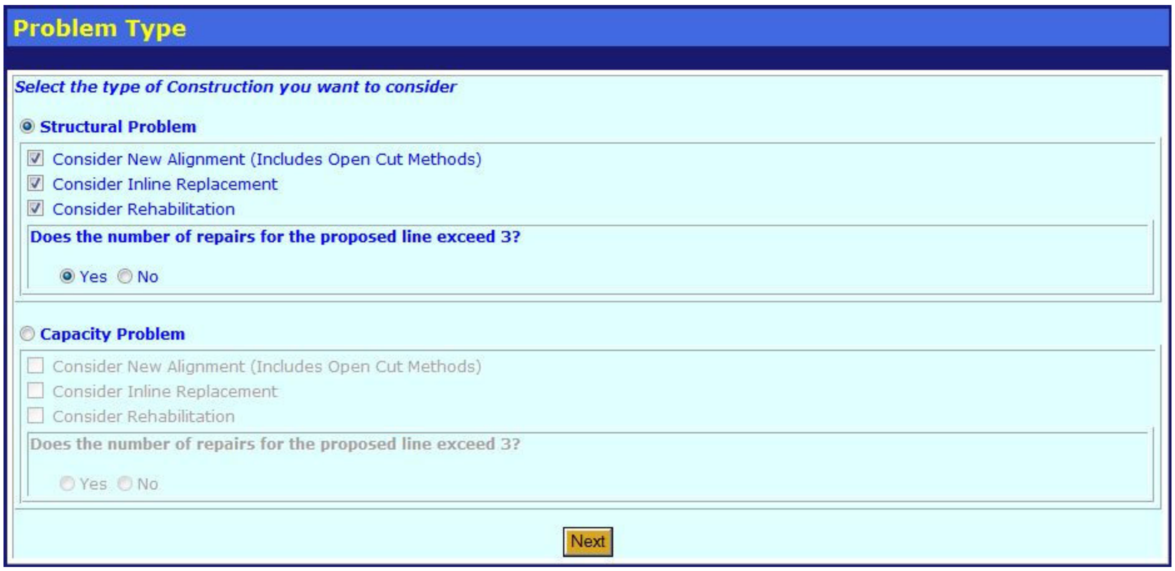


Only one construction method was found to satisfy all of the project's technical requirements. Microtunneling Slurry was considered to offer a relatively low level of risk/potential for adverse impact when compared to project parameters. Some other methods might be able to complete the installation described above, but only Microtunneling Slurry is found to be viable based on the recommended and reasonable data found in the database.

C.2. CASE STUDY 2

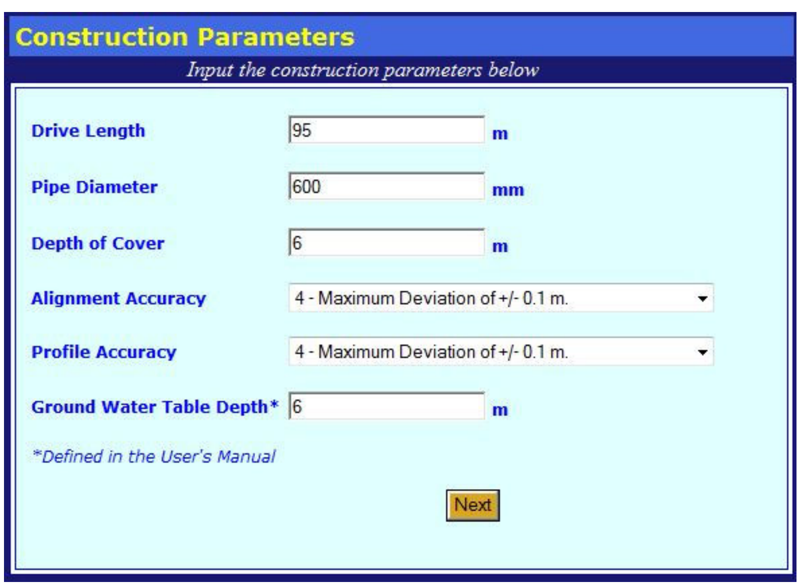
C.2.1. Problem Selection

The second case history is from the City of Calgary, AB, Canada, which was trying to identify a suitable repair methodology for a deep sewer located in the downtown area.

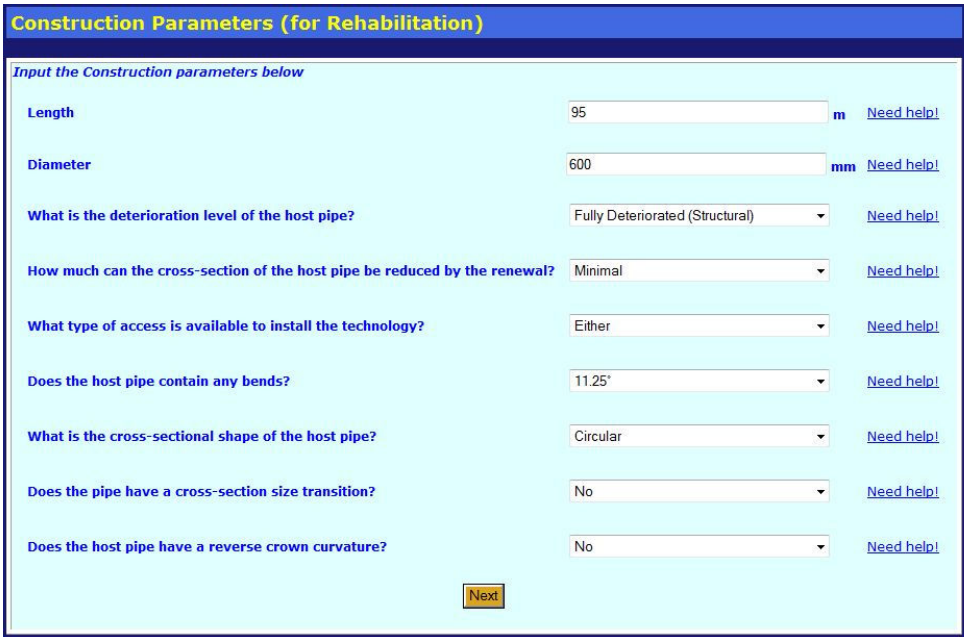


C.2.2. Project Input

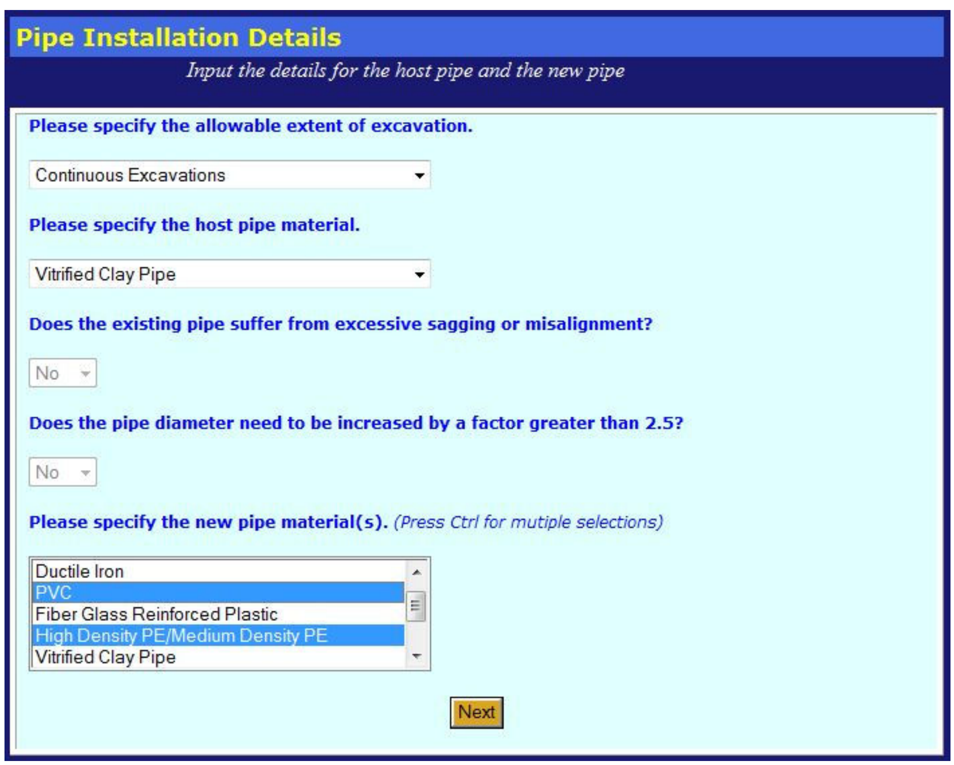
The gravity driven sewer was a 95 m (300 ft.) long, 600 mm (24 in.) diameter vitrified clay pipe, with an average depth of about 6 m (20 ft.). The input form for the inline replacement data is shown below.



Based on CCTV inspection data it was concluded that the host pipe was fully deteriorated, and thus a structural solution capable of resisting earth loads, any relevant live loads and the hydrostatic pressure applied by the groundwater was needed.



Soil conditions and the host and new pipe details are input next. Typical soil conditions in Calgary's down town area consists of river valley flood plain deposits (a mix of medium sand, 70%; and gravel, 30%). As for the replacement pipe, PVC and HDPE pipes were considered as the best options.



C.2.3. Results

The detailed project data was input into TAG Online, which identified static pipe bursting as the least risky construction approach. TAG also identified structural cured-in-place pipe (CIPP), structural folded pipe and spiral wound lining as viable rehabilitation technologies for the pipe in question. The City of Calgary initially selected static pipe bursting as the construction method of choice for this project, but decided to opt for pneumatic pipe bursting once it was determined that no utilities were sufficiently close to be disrupted by the method and the project was completed successfully, on time and budget.


Congratulations!

Category	Method	Relative Risk	Risk Score
IL Method	Pipe Bursting Pneumatic	Moderate Risk	2.61
IL Method	Pipe Bursting Hydraulic	Moderate Risk	2.61
IL Method	Pipe Bursting Static	Moderate Risk	3.01
TT Method	HDD Midi	Moderate Risk	3.01
OC Method	Open Cut Excavation	Moderate Risk	3.01

Modify Risk Analysis input

4 suitable rehabilitation method(s) were found!

Category	Method
Rehabilitation Method	CIPP Inversion (Structural) 2
Rehabilitation Method	CIPP Pulled In (Structural) 2
Rehabilitation Method	Folded Pipe (Structural) 3
Rehabilitation Method	Spiral Wound (Non-Grout)

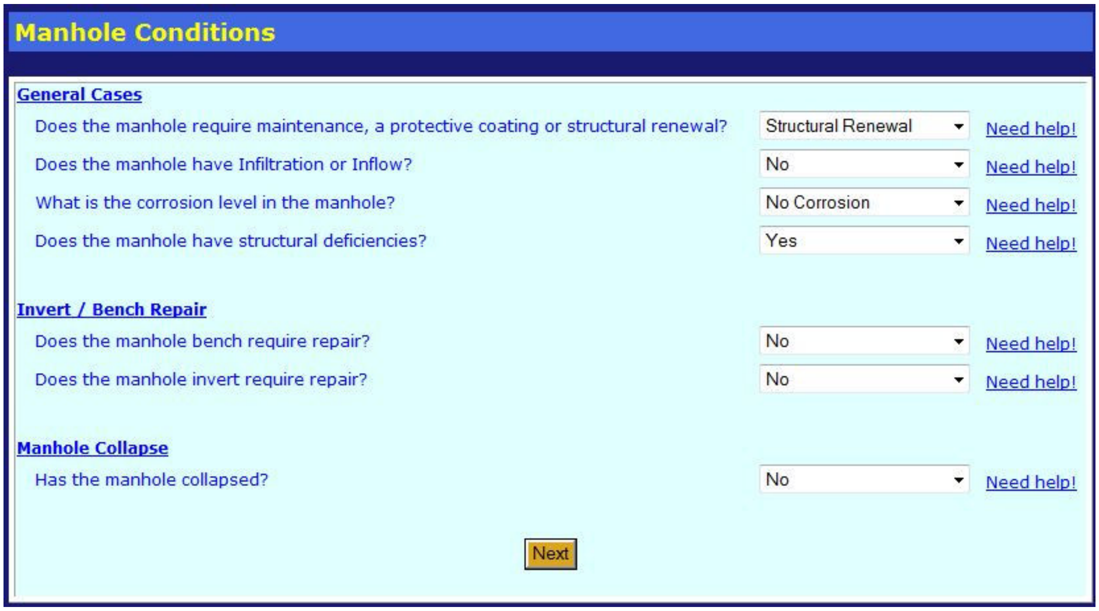
C.3. CASE STUDY 3

C.3.1. Problem Selection

TAG is also capable of identifying suitable manhole rehabilitation methods based on standard condition assessment data. The evaluation is based on the following conditions: level of infiltration/inflow, level of corrosion, structural integrity, and the condition of the bench and invert. This capability is demonstrated by assessing the following project undertook by the City of Columbus in 2003.

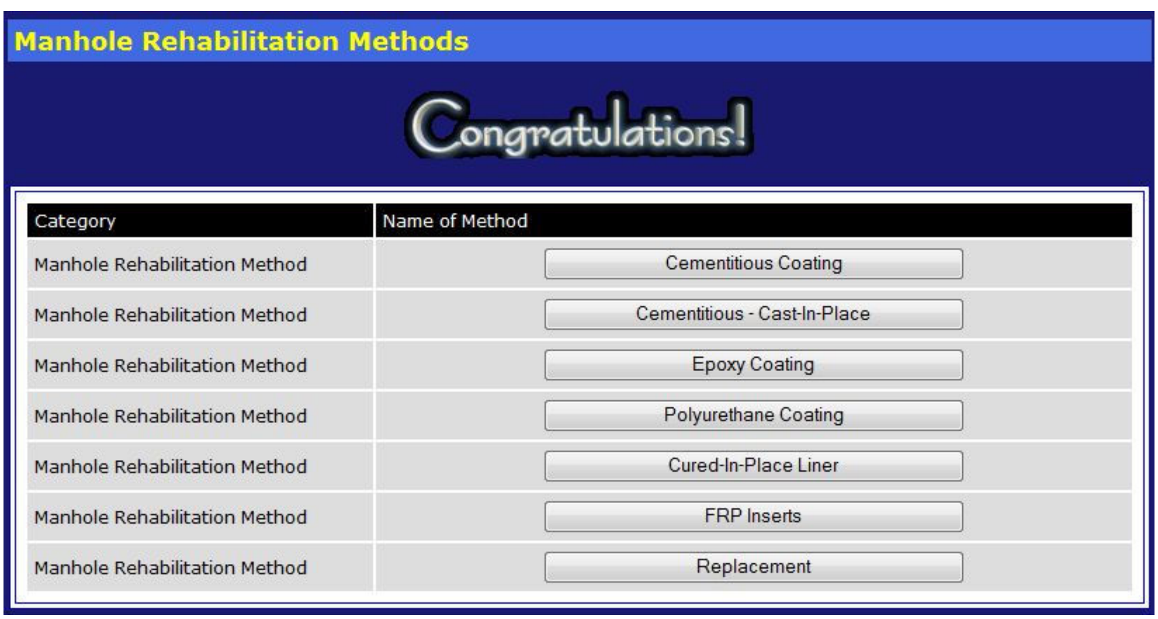
C.3.2. Project Input

Segment 1 of the Franklin-Main interceptor sewer consists of 580 m. (1900 ft.) of 600 mm. (24 in.) vitrified clay at depths of up to 5 m. (15 ft.) that was originally constructed in 1913. The sewer extends through heavily developed residential areas and is adjacent to the Olentangy River. Review of CCTV images revealed that between a third and a half of the sewer cross-sectional area was filled with debris. The maximum ovality in the host pipe was less than 10% and the pipe was considered to be only partially deteriorated. It was also decided that by-passing of the line for the duration of the project was doable. There were no significant bends (greater than 12°) in the host pipe or cross-section transitions. The design report concluded that the entire length of the pipe should be rehabilitated using CIPP, and each of the existing manholes rehabilitated with cementitious linings to improve their structural integrity.



C.3.3. Results

The program suggested that only CIPP or a Spiral wound liner could be used to rehabilitate the 580 meters of interceptor sewer in a single operation. While identifying cementitious coating as a viable rehabilitation method for the manholes, TAG suggested that several alternative approaches might also be deemed adequate for this project.



D. RISK SCORE

D.1. COMPUTING A METHOD'S RISK SCORE

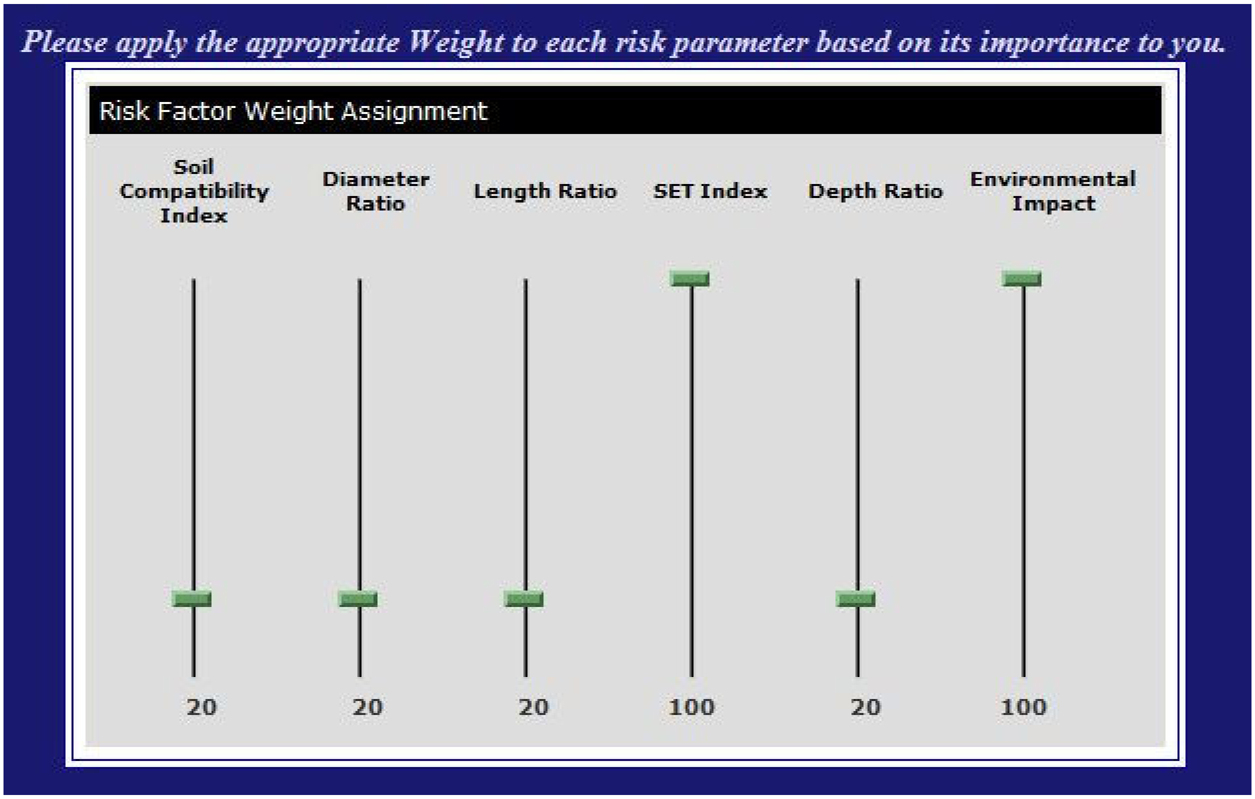
This section provides additional insight into the mathematical formulation used for calculating the risk score for each construction method. The risk score is the weighted average of six contributing risk factors. Four of these factors (Length Ratio, Diameter Ratio, Depth Ratio and Soil Compatibility Index) reflect the level of comfort with which a construction method meets the project's technical requirements. In other words, regardless of whether the installation length is at the 25th or 95th percentile of the method's range, the method will be deemed technically viable. However, it is argued that the potential risk in the latter case is greater than it is in the former case. The relative level of risk is expressed as the ratio of the installation's length to the maximum installation range of the method under consideration. The same rationale is applied to the depth of installation and product diameter.

For soil compatibility, the level of risk is based on the percentage of **Possibly Compatible** soils along the project's alignment. For example, in the second case study soil conditions were specified as: medium sand (60%); stiff hard clay (35%); and gravel (5%). If a method is only possibly compatible with medium sand and gravel (65% of alignment), and fully compatible with hard clay then the perceived risk is considered to be higher than if the method was fully compatible with medium sand and stiff hard clay, but only possibly compatible with gravel (5% of alignment).

The remaining two parameters that comprise the risk score measures of the owner's level of comfort with the method (direct experience, method's track record, and availability of specifications) and the potential adverse impact on the natural and built environments.

A user might choose to give all contributing parameters an equal degree of importance (i.e., weight) or different degrees of importance. In some cases, the user might choose to completely ignore some of the parameters. Adjusting the importance of a given factor is accomplished by dragging the 'handle' on the sliding bar with the mouse.

As an example, let us assume that the owner in Case Study 2 has an established working relationship with a competent and environmentally conscious HDD contractor. Thus, the owner wishes to re-run the analysis giving lower weights to the four technical aspects. The following screen shot shows the **SET Index** and **Environmental Impact** factors set to 100% (or high importance), while the remaining contributing factors are set to 20% (or low importance).



The impact of modifying the weights of the contributing factors on the risk final score is shown below. The same five construction methods were identified by the program. However, the risk score for HDD Midi was decreased from 3.01 to 2.87 while all other risk scores increased. This shows that the owner's comfort with an HDD contractor can effectively place HDD as the preferred method relative to the project data.

Category	Method	Relative Risk	Risk Score
TT Method	HDD Midi	Moderate Risk	2.87
IL Method	Pipe Bursting Pneumatic	Moderate Risk	3.26
IL Method	Pipe Bursting Hydraulic	Moderate Risk	3.26
IL Method	Pipe Bursting Static	Moderate Risk	3.40
OC Method	Open Cut Excavation	High Risk	3.59

E. APPENDIX

E.1. DEFINITION OF PROGRAM PARAMETERS

Many of the method parameters listed in the construction method database are listed by their classifications which must be defined to fully understand the methods' capabilities. The following parameters are defined below: soil compatibility, environmental impact, extent of excavation, groundwater table classification, alignment accuracy and profile accuracy.

E.1.1. Soil Compatibility

The construction method database contains soil compatibility information for ten categories of geological conditions, with soil types being further quantified in terms of the number of blows per foot (as per ASTM 1452). The geological conditions considered by TAG are:

Soils	Blows per Foot
Soft Cohesive Soils	(N < 5)
Firm Cohesive Soils	(5 < N < 15)
Stiff Hard Cohesive Soils	(N > 15)
Loose Cohesionless Soils	(N < 10)
Medium Cohesionless Soils	(10 < N < 30)
Dense Cohesionless Soils	(N > 30)
Gravel	-
Cobble / Boulders	-
Sandstone	-
Bedrock	-

The compatibility of each construction method with the ten soil classes is designated as either:

Compatibility	Database Symbol
Fully Compatible	(Y)
Possibly Compatible	(P)
Incompatible	(N)

E.1.2. Environmental Impact

The values for potential environmental impact are provided with a relative ranking in the construction method database. These values are based on many factors which include: potential for ground settlement and heave (potential damage to paved surfaces, nearby utilities and foundations); erosion; removal of trees and flora; creation of temporary hazards (i.e. open trenches); and the potential for the migration of drilling fluids to the surface.

Environmental Impact	Database Symbol
Very Low	1
Low	2
Medium	3
High	4
Very High	5

E.1.3. Extent of Excavation

The values for allowable extent of excavation are fixed in the construction method database.

Extent of Excavation	Database Symbol	Methods
Continuous Excavations	1	All methods can be used
Limited Excavations	2	Excludes backhoe excavation
Access/Receiving Pits Only	3	Excludes all open cut methods

E.1.4. Groundwater Table Classification

The technical feasibility of certain trenchless construction methods is conditioned upon the height of the hydrostatic head acting on the cavity; in other words, the elevation of the proposed alignment with respect to the elevation of the groundwater table (GWT). The values for groundwater table classification are fixed in the construction method database.

Groundwater Table Classification	Database Symbol
Can handle at least 10 ft. of hydrostatic head	C1
Can handle up to 10 ft. of hydrostatic head	C2
Can handle up to 3ft. of hydrostatic head	C3

The formula for height of hydrostatic head is as follows:

Hydrostatic Head, ft. = (Depth of the Installation, ft.) – (Pipe Diameter, ft.) – (Depth of GWT, ft.)

E.1.5. Alignment and Profile Accuracy

These parameters refer to the anticipated level of installation accuracy that will be needed.

Accuracy	Database Symbol	Description
Very Low	1	No Steering Capabilities
Low	2	Limited Steering Capabilities
Medium	3	Dedicated Tracking and Steering Capabilities
High	4	Maximum Deviation of +/- 4"
Very High	5	Maximum Deviation of +/- 2"

E.2. DEFINITION OF REHABILITATION PARAMETERS

The rehabilitation parameters can be defined by clicking the Need Help links next to their names on the input screens. The following parameters are defined below: length, diameter, pipe deterioration, cross-section reduction, pipe access, bends, shape, size transition, reverse curvature, service connection and lateral access.

E.2.1. Length

The maximum length of any host pipeline section on the project to be renewed.

E.2.2. Diameter

The diameter of the host pipe which requires renewal.

E.2.3. Pipe Deterioration

<u>Partially Deteriorated (Non-Structural)</u>
The original pipe can support the soil and surcharge load throughout the design life of the rehabilitated pipe. The soil adjacent to the existing pipe must provide adequate side support. The pipe may have longitudinal cracks and up to 10% distortion of the diameter.

<u>Fully Deteriorated (Structural)</u>
The original pipe is not structurally sound and cannot support soil and live loads, nor is it expected to reach this condition over the design life of the rehabilitated pipe.

E.2.4. Cross-Section Reduction

<u>Small</u>
A tight fitting field manufactured renewal system with no annular space between the host pipe and the new liner system.

<u>Medium</u>
A loose fitting factory manufactured pipe inserted into the host pipe can be designed with or without the use of annular space grout.

<u>Large</u>
A significantly smaller pipe inserted into the host pipe.

E.2.5. Pipe Access

<u>Manhole</u>
Includes technologies that, due to their size and material make-up, can be installed directly through a manhole opening of the existing pipe.

<u>Access Pit</u>
Includes technologies that, due to their size and material make-up cannot be installed directly through a manhole opening of the existing pipe.

E.2.6. Bends

For bends not listed in the selection menu choose the next highest degree bend.

E.2.7. Pipe Shape

For other pipe shapes contact the product manufacturers directly.

E.2.8. Size Transition

A cross-section size transition may be encountered in a constructed in place brick pipe. Some technologies can accommodate this type of size change. A point repair, where a smaller diameter pipe is installed to repair a larger pipe, is not considered a cross-section pipe size change and should be replaced before renewing the host pipeline.

E.2.9. Reverse Curvature

When the crown of the pipe (typically in brick pipe) begins to collapse and forms a reverse curvature, technologies that rely on an arch design, no longer are applicable as a structural design solution. A reverse arch configuration can be lined with a smaller round pipe and then back-grouted to provide a structural solution.

E.2.10. Service Connection

<u>No Service Connections</u>
The pipe has no domestic or commercial connections in the section being renewed.

<u>Internally</u>
The service connections in the new pipe can be opened internally to provide the applicable level of service.

<u>Externally</u>
The service connections must be reconnected externally to provide the required level of service.

<u>Either</u>
The service connections can be connected by either method to provide the required level of service.

E.2.11. Lateral Access

<u>Cleanout</u>
Includes technologies that, due to their size and material make-up, are installed from a cleanout to the mainline sewer.

<u>Manhole, Access Pit or Cleanout</u>
Includes technologies that, due to their size and material make-up, are installed from the mainline sewer to a cleanout or access pit.

E.3. DEFINITION OF MANHOLE PARAMETERS

The manhole parameters can be defined by clicking the Need Help links next to their names on the input screens. The following parameters are defined below: condition, infiltration/inflow, corrosion, structural deficiencies, bench repair, invert repair and collapse.

E.3.1. Condition

General Maintenance

The manhole is considered structurally sound with little indication of settlement, cracking or other signs of structural fatigue including minor corrosion, infiltration or exfiltration through precast joints, mortar joints or around the pipe connections.

Protective Coating

The manhole is exhibiting early signs of structural fatigue evidenced by minor cracks, loss of mortar or brick, corrosion (less than 0.5 in. in depth), minor cross sectional distortion (less than 10 %); however the existing structure is currently supporting the soil and live loads.

Structural Renewal

The manhole is exhibiting severe structural fatigue and collapse is eminent. Conditions indicating this degree of deterioration would be distortion beyond 10 %, severe corrosion (exposed reinforcing) or large sections of the existing structure are missing.

E.3.2. Infiltration/Inflow

Infiltration

Typically groundwater that flows into the manhole through joints, cracks, bench, invert, pipe connections, etc.

Inflow

Typically runoff water during a rainfall event that flows through manhole cover holes, between the casting and the chimney.

E.3.3. Corrosion

No Corrosion

The manhole is in very good condition with some of the brick mortar or concrete surface in a solid hard condition.

Light Wall Corrosion

The brick mortar is deteriorated and missing or concrete surfaces are soft and flaking in spots.

Heavy Wall Corrosion

Bricks and mortar are missing in a number of areas of the manhole or several inches of soft concrete wall and sections of the wall surface are missing.

E.3.4. Structural Deficiencies

Yes

Bricks are missing in a number of areas of the manhole with distortion of the manhole wall. Concrete manholes with portions of the wall missing, rebar's showing or missing.

No

The manhole is generally in good structural condition.

E.3.5. Bench Repair

Yes

The manhole bench is cracked and deteriorated with sections missing, bench does not exist or groundwater is infiltrating at the bench.

No

The bench is generally in good condition and channels the flow in the intended direction.

E.3.6. Invert Repair

Yes

The invert is missing or eroded, pipe running through the invert is fractured and dislodged or the elevation does not match the elevations of the incoming and outgoing pipe elevations.

No

The invert is in good shape and directs the flow through the manhole in the intended direction. The invert provides a smooth transition of flow from the incoming pipe to the outgoing pipe.

E.3.7. Collapse

Yes

The manhole wall has partially collapsed and requires that it be totally rebuilt with a structurally sound lining system or new structure.

No

The manhole is a candidate for one or more of the many coating and/or lining systems available.