APPENDIX E

TEXN2.2 UTILITY UPDATES FOR COMPATIBILITY WITH THE US EPA MOVES3 MODEL

Navarro County Attainment Demonstration State Implementation Plan for the 2010 One-Hour Sulfur Dioxide National Ambient Air Quality Standard

2021-012-SIP-NR

TCEQ Contract 582-19-92744
TCEQ Work Order 582-21-11300-002
ERG Deliverable 7.2

Eastern Research Group, Inc.

TexN2.2 Utility Updates for Compatibility with the US EPA MOVES3 Model

Final Report

Prepared for:

Texas Commission on Environmental Quality
Air Quality Division

Prepared by:

Eastern Research Group, Inc.

April 23, 2021

ERG No. 0422.00.002

TexN2.2 Utility Updates for Compatibility with the US EPA MOVES3 Model

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ACRONYMS

AERR - Air Emissions Reporting Requirements

BSFC – Brake-Specific Fuel Consumption

CDB – County Database

CNG – Compressed Natural Gas

DCE – Diesel Construction Equipment

DFW – Dallas-Fort Worth

EI – Emission Inventory

ERG – Eastern Research Group

FIPS – Federal Information Processing Standards

GUI – Graphical User Interface

HC – Hydrocarbon

HGB – Houston-Galveston-Brazoria

HP – Horsepower

JSON – JavaScript Object Notation

LPG – Liquefied Petroleum Gas

MOVES – Motor Vehicle Emissions Simulator

NEI – National Emissions Inventory

NO_x – Nitrogen Oxide

PM_{10} – Particulate Matter (less than 10 microns)

QA – Quality Assurance

QAPP – Quality Assurance Project Plan

OSD – Ozone Season Day

RFP – Reasonable Further Progress

SCC – Source Classification Code

SQL – Standard Query Language

TCEQ – Texas Commission on Environmental Quality

TPD – Tons Per Day

TPY – Tons Per Year

TexN – Texas Nonroad version 1 utility, compatible with NONROAD model

TexN2 – Texas Nonroad version 2 utility, compatible with MOVES model

TxLED – Texas Low Emission Diesel

VOC – Volatile Organic Compounds

I. INTRODUCTION

The purpose of this project was to update the Texas Commission on Environmental Quality's (TCEQ) Texas NONROAD version 2 (TexN2) utility to be compatible with the latest United States Environmental Protection Agency (EPA) Motor Vehicle Emission Simulator (MOVES) model, called MOVES3. Eastern Research Group (ERG) identified and implemented all code updates required to ensure that the prior TexN2.1 utility is fully compatible with MOVES3. In addition, ERG added enhancements to the utility to streamline the way TexN2 handles alternative equipment scrappage curves and generates county databases (CDBs) for submittal for the Air Emissions Reporting Requirements (AERR) and National Emissions Inventory (NEI). The resulting new TexN2 utility is called TexN2.2.

The TCEQ contracted with ERG to develop the TexN and TexN2 models, which are utilities for estimating Texas-specific emissions from nonroad mobile sources, excluding commercial marine vessels, locomotives, drilling rigs, and aircraft. The TexN model used EPA's NONROAD model to calculate emissions, while TexN2 uses EPA's MOVES2014b Nonroad model. MOVES is required by the EPA for developing nonroad emissions estimates for state implementation plan revisions, national emissions inventories, and reasonable further progress analyses. Since TexN was first developed, the TCEQ has frequently updated the Texas-specific data and enhanced the utility's functions.

Recently the EPA updated their MOVES model, releasing MOVES3 this past November (US EPA, 2020). The EPA currently requires states to use the most recent version of the MOVES model when developing and submitting emissions estimates from nonroad mobile sources.

This report presents a comprehensive overview of the activities undertaken during the project. The report highlights major activities, quality assurance (QA) results, instructions for how to replace the previous TexN2.1 utility, and recommendations for further improvements. The updated utility, named TexN2.2, and associated supporting files have been provided to the TCEQ electronically. Directions on how users can update to the latest version, TexN2.2, are provided in Section V and can be found in the utility User's Guide available from the TCEQ upon request. Appendix A contains information about EPA default updates to calendar year 1990 populations for equipment in diesel construction equipment (DCE) subsectors 0 and 25.

II. UPDATING TEXN2 TO MOVES3

This section is organized into three subsections. The first subsection documents the starting point version of TexN2 for the update work and discusses version naming conventions for TexN2 going forward. The second subsection briefly describes the developer environment for Task 3 and all future work on TexN2. The third and final subsection describes each change made to the TexN2 utility to make it compatible with MOVES3. Additional changes to TexN2 are documented separately in Section III and V.

Starting Point TexN2 Utility and Software Naming Conventions

The utility name "TexN2" is a generic name for TexN version 2 that works with MOVES. TexN2 is a fundamentally different utility than "TexN" which worked with EPA's standalone NONROAD model. The prior version of TexN2 has been commonly referred to as "TexN2.1" by the TCEQ and ERG following significant recent database updates on equipment population, activity, and load factors (ERG, 2020). The official source code version of "TexN2.1" was 0.1.2 and TexN2 database version TexN2_21aug20.sql. These were the starting points for the current project.

ERG electronically delivered a new version of TexN2 called "TexN2.2" with a source code version 2.2.0. The three positions in the version correspond to Major.Minor.Patch and indicate the significance of revisions. If any patches to TexN2.2 are needed in the future, the TexN2 version 2.2.0 will be updated using the third position (for example: 2.2.1 for the first patch). This software naming convention is consistent with what US EPA has adopted for MOVES3. At the time of writing, the MOVES3 source code is version 3.0.1. TexN2 users can always verify their version from the Graphical User Interface (GUI) main menu bar by selecting About, then Version.

Software Development Environment

ERG stores the TexN2 source code on the Git-based source code repository hosting service website called Bitbucket. The ERG TexN2 development team members each have local developer environments on our Windows PCs with all software components needed to build TexN2, including:

- The file version tracking software Git[1],
- Bitbucket[2] accounts,
- Python interpreter (64-bit version Python 3.7 for Windows)[3],
- Python modules that support data manipulation, Excel file writing, reporting, Structured Query Language (SQL) connectors, etc.,

[1] http://gitforwindows.org

[2] https://bitbucket.org/

[3] http://www.python.org/downloads

- Qt Creator[4] software to develop the TexN2 GUI

TexN2 Source Code Updates

While the main purpose of the updates was MOVES3 compatibility, ERG made a number of other improvements while accessing the code.

Changes to TexN2 for compatibility with MOVES3 included:

- Added new database connection support for MariaDB.
- Enabled flexibility in the MariaDB port number.
- Enabled the future years 2051-2060 that MOVES3 added.
- New command line language to launch MOVES3 master and workers.
- Updates to the TexN2 pollutant lists to align with MOVES3.
- Updates to the MOVES run specification (runspec) file template.

Other changes to TexN2 that are general improvements included:

- Flexibility in the MOVES database version required for the first-time launch of TexN2, instead of requiring a specific version.
- Limit the size of the TexN2.log file.
- Fixed bugs in the QA checks.
- Updated the TexN2 function "Generate CDBs for NEI" function to bring the output CDB contents and names into alignment with US EPA requirements.

The new database connection support for MariaDB was required in several of the source code python modules, including mysql_classes.py and cdb.py. Recognizing that TexN2 users may have both MOVES2014b (or earlier) and MOVES3 installed on the same machine, users may also have both MySQL and MariaDB installed on the same machine. For background information, MySQL and MariaDB must occupy different port numbers, and the most likely scenario is that MySQL will occupy the default port (3306) and MariaDB will be assigned the next port number (3307). However, TexN2 users may have configured MariaDB to occupy port 3306 or some other number. Users will need to know their MariaDB port number and specify it in a new TexN2 pop-up window that now appears the first time TexN2 is run (Figure 1).

[4] https://download.qt.io/official_releases/online_installers/

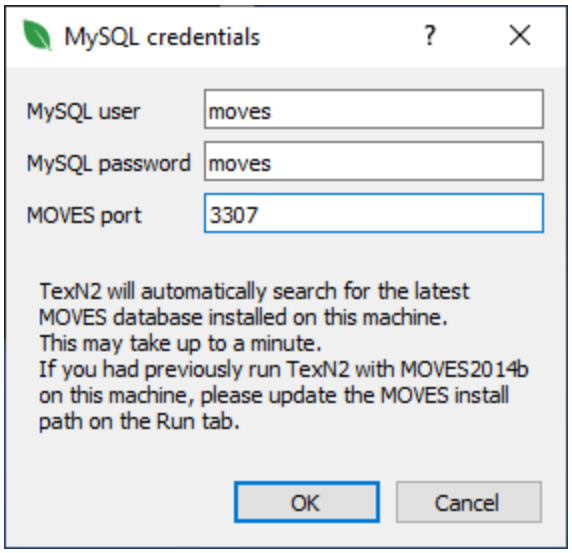


Figure 1. First-time TexN2 Launch Window requesting MySQL Username and Password and the MOVES port for MariaDB.

The MySQL credentials window above in Figure 1 only appears for the first-time launch of the new TexN2 utility. Subsequent launches remember the initial settings from storage in the file C:\Users*YourUserName*\AppData\Local\ERG\TexN2.ini.

MOVES3 extended the range of calendar years, adding 2051 to 2060. Previously, TexN2 with MOVES2014b could run only calendar years 1999 through 2050. ERG added the new years to the GUI Scenario tab drop down menu for the year (Figure 2) and extended several database tables to cover years 2051-2060 including nonroad equipment populations. For now, the equipment populations are held constant after year 2050 into the future (no growth assumption). These future year populations could be updated in the future when data become available.

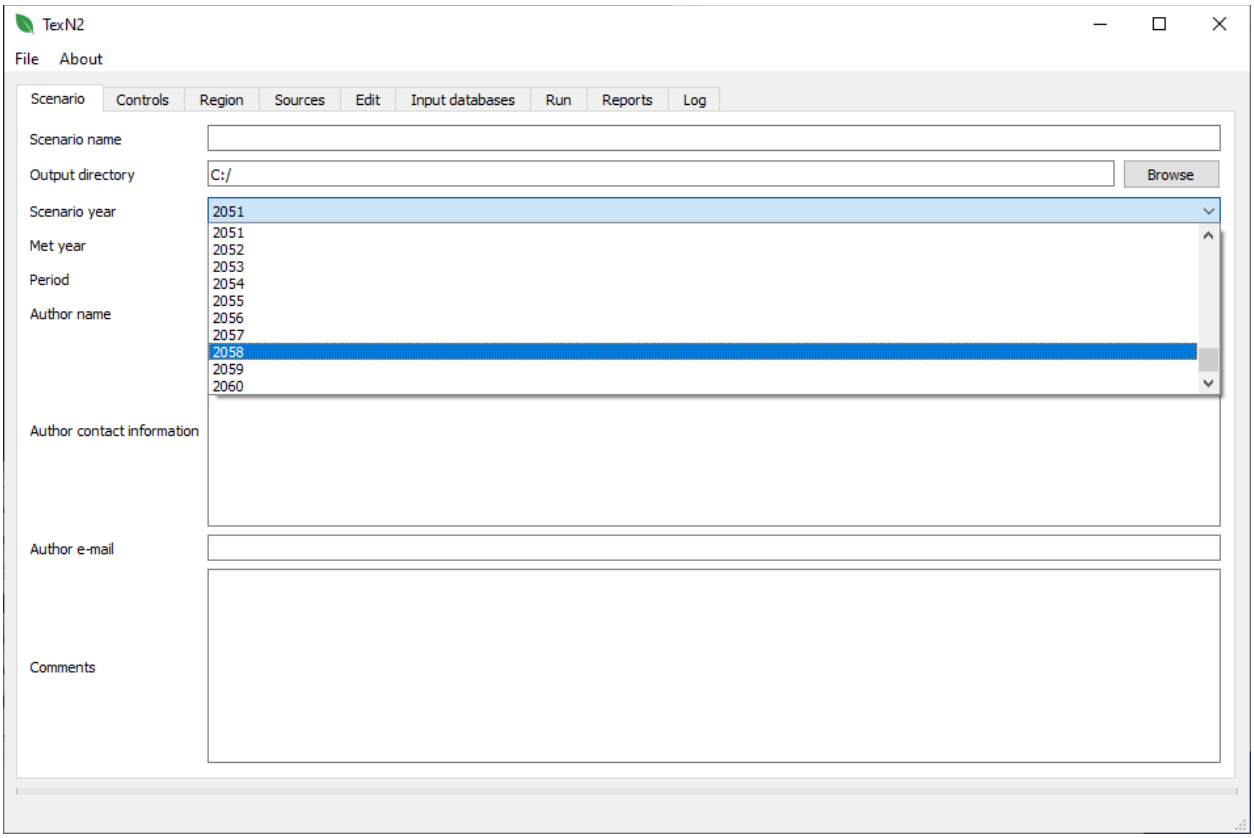


Figure 2. New Future Years in TexN2 with MOVES3

TexN2 runs MOVES from the command line (i.e., without the use of the MOVES GUI). MOVES3 changed the commands required for command line launching of master and workers. ERG updated the TexN2 utility accordingly to write executable batch files correctly for MOVES3. The changes are printed in the text box below.

Launch Multiple MOVES Workers from the Command Line (e.g., 7 workers)

Old: `ant 7workers -Dnoshutdown=1`

New: `ant -Dmaxworkers=7 manyworkers -Dnoshutdown=1`

Launch the MOVES Master from the Command Line

Old:
```
java -Xmx1200m gov.epa.otaq.moves.master.commandline.MOVESCommandLine
-r InputRunspecFileName > OutputLogFileName
```

New: `ant run -Drunspec=InputRunspecFileName > OutputLogFileName`

ERG also updated the template MOVES runspec file to MOVES3 format and changed pollutant lists to remove methyl tert-butyl ether which is not included in MOVES3.TexN2 uses the template MOVES runspec to build many individual MOVES runs corresponding to the counties and DCE subsectors selected in a TexN2 scenario.

The next several updates discussed are general improvements, not specific to MOVES3. The first time a user launches the new utility, they must already have MOVES installed which includes a MOVES database. EPA's current MOVES3 database is movesdb20210209, and later releases are expected to be named with the convention movesdbYYYYMMDD. The updated TexN2 utility will now look for the latest version of the MOVES database in the MariaDB localhost for a first-time launch of the utility. The user may change the MOVES database version (as well as the MOVES port for MariaDB, MySQL username, and password) at any time in the Run tab of the GUI (Figure 3). The TexN2 GUI requires connection to a MOVES database to populate the source classification code (SCC) lists in the Sources tab and other information. This improvement replaces an older workaround described in previous TexN2 User Guides; those descriptions have been removed from the TexN2.2 User Guide.

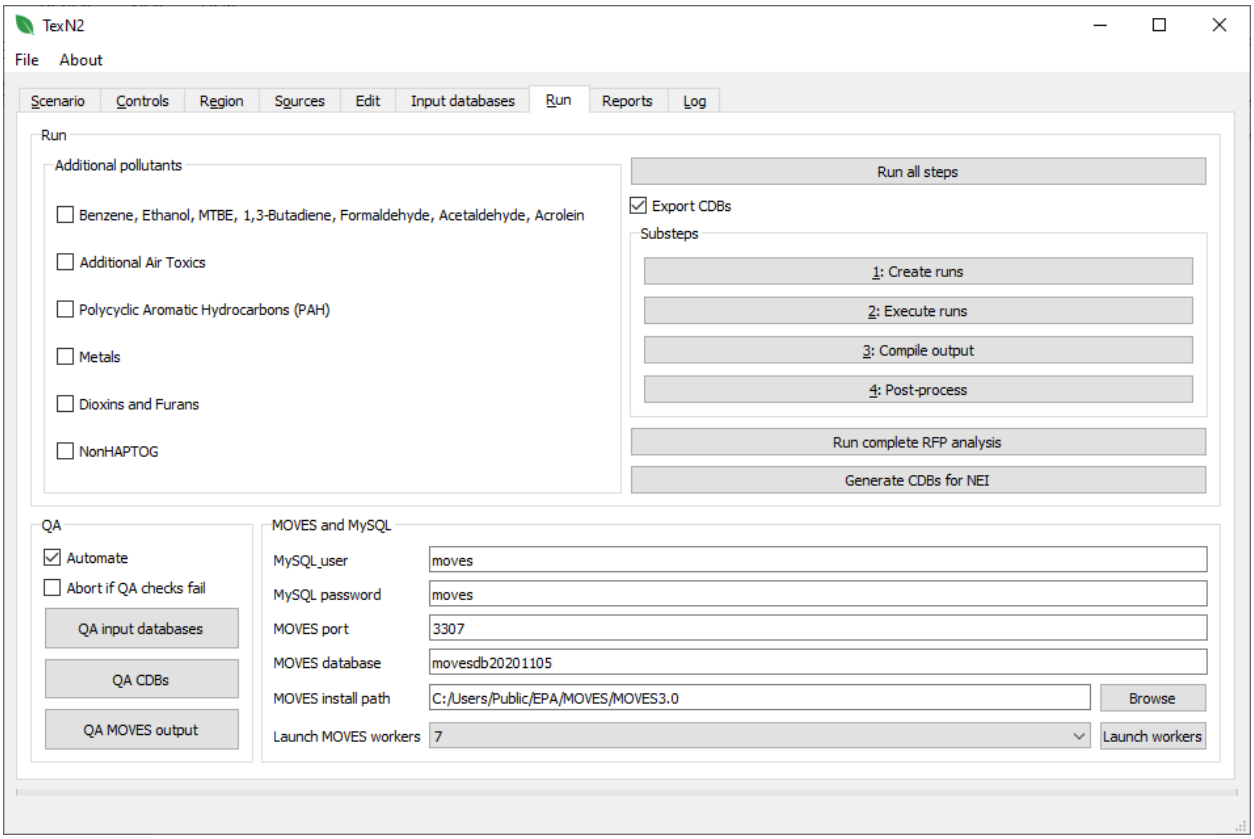


Figure 3. TexN2.2 Run tab

In response to TCEQ staff encountering large TexN2 log files, another general improvement to TexN2.2 was setting a maximum file size on the log. In previous versions of TexN2, the TexN2.log file recorded all MySQL query performed on any CDB. As a result, for large statewide runs with hundreds of CDBs, the TexN2.log file size would become too large, reaching as large as 300 gigabytes. ERG implemented a new logging approach that limits file size while still retaining information useful to troubleshooting. The new maximum file size is approximately 4 megabytes.

While running benchmark tests of TexN2, ERG discovered and fixed two bugs in the QA checks that occur during partially controlled runs. ERG also found two minor bugs in MOVES3-Nonroad during Task 3, reported them to US EPA, and received responses acknowledging that both are now corrected and were included in a MOVES3 patch update along with other minor updates.

The last general improvement ERG made was an overhaul of the "Generate CDBs for NEI" button in the Run tab of the TexN2 GUI. This function produces MOVES CDBs consistently (to the extent possible) with the inputs for TexN2 standard emission inventory (EI) runs, while meeting EPA's requirement of one CDB per county. In past versions of TexN2, this function developed alternative base emission rates to force a match on the emissions results from an EPA run with one CDB per county and a disaggregated TexN2 run with unique SCC activity and age distributions from different DCE subsectors. During the 2017 NEI submittal period, the US EPA informed TCEQ that they cannot accept alternative nonroad emission rate tables from states for the NEI. As a result, much of the work TexN2 was performing to "Generate CDBs for NEI" became unnecessary. ERG updated the function by stopping all MOVES runs (whose purpose was to develop the emission factor adjustments) and limiting its function to produce a set of aggregated CDBs that represent the closest approximation of standard TexN2 runs. In addition, ERG changed the naming convention of the final CDBs to follow EPA's requirements of cXXXXXy2020_nr_YYYYMMDD, where the first six digits are the letter 'c' followed by the 5-digit state-county Federal Information Processing Standards (FIPS) code, y2020 is the NEI year (2020), and YYYYMMDD is the version date, the date the CDB was created. The function now places the new CDBs into the TexN2 output directory. Benchmark run number 6 in this document further discusses the updates and outputs.

III. STREAMLINING ALTERNATIVE SCRAPPAGE

Definition of Scrappage

In nonroad emissions modeling, *scrappage* refers to a non-dimensional survival curve that provides survival rates in percent on the Y-axis against fraction of the engine life used (US EPA, 2002). The engine life used runs from zero (0) to two (2) times the average useful life of the equipment. The value of one (1) on the X-axis is the median useful life, and EPA assumes that half the equipment will retire before the median useful life and half will retire after. EPA's default curve is shown in blue in Figure 4. The default curve has an S-shape and starts at zero engine life used.

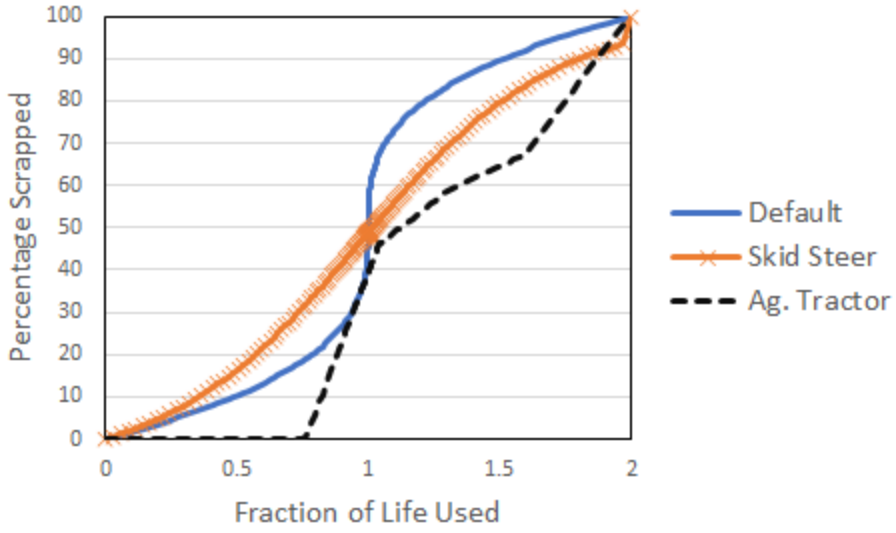


Figure 4. MOVES Default and two TexN2 Alternative Scrappage Curves for Skid Steer Loaders and Agricultural Tractors

The MOVES model uses scrappage to determine the age distribution of nonroad equipment, which has a large impact on emissions due to different emission standards by model year.

EPA's standalone NONROAD model was designed to handle alternate scrappage curves (US EPA, 2002), but the functionality has not been carried over to MOVES as of the time of writing (April 2021). ERG previously remedied this MOVES limitation by adding MySQL queries to the supporting files of the prior TexN2.1 to automatically detect when a utility user isolated either case of SCC and DCE combination: (1) Diesel Agricultural Tractors in the Non-DCE subsector, or (2) Diesel Skid Steer Loaders in the Skid Steer Loader DCE subsector. When either case was isolated by the user, TexN2 placed the appropriate alternate scrappage curve into the MOVES county input databases. That prior enhancement to enable the Texas scrappage curves

unfortunately required work on the part of the user to split up input files into three parts, run three scenarios, and sum emissions from three report summaries to arrive at the total emission inventory. The TexN2 source code changes described below automatically split these two combinations of SCC and DCE subsector from other MOVES runs, thereby always using the best available scrappage curves without any action by the user.

TexN2 Source Code Updates

Our general approach to have TexN2 to split up MOVES runs based on SCC/DCE began with setting up a small test case JavaScript Object Notation (JSON) file that would test but was intended to fail to use any alternative scrappage curves (prior to code updates). The test case scope was kept intentionally small to facilitate quick TexN2 runtimes: three SCCs operating in up to two DCE subsectors for one Texas county. Table 1 lists the five combinations of SCC and DCE subsector for the small test case. With this test setup, ERG was able to iteratively test the impact of TexN2 source code changes and obtain quick feedback on the impacts.

Table 1. Sources Included in the Test Case for Iterating Code Updates

SCC	DCE Subsector	Combination
2270002036 Diesel Excavators	5 – Commercial Construction	1
	18 – Skid Steer Loaders	2
2270002072 Diesel Skid Steer Loaders	18 – Skid Steer Loaders	3*
	25 – Off-Road Tractors, Misc. Equipment, and all Equipment < 25 hp	4
2270005015 Diesel Agricultural Tractors	0 – Non-DCE	5*

*Combinations of SCC/DCE with Alternate Scrappage

The module *scenario.py* is responsible for dividing up MOVES runs based on user selections of SCC and DCE in the JSON file. The prior utility's *scenario.py* module assigned these five categories from the test case into just two runs, each without any alternate scrappage, because ERG ran all combinations in a single JSON. This was the expected result. ERG then added conditional statements (if/else) to the scenario.py module to isolate the Combinations 3 and 5 in Table 1 above. Tests of the new code showed the expected, correct "after" result of additional MOVES runs created by the same scenario.

Before

- Run #1: 2270002036 (DCE 5), 2270002072 (DCE 18), and 2270005015 (DCE 0)
- Run #2: 2270002036 (DCE 18) and 2270002072 (DCE 25)

After

- Run #1: 2270002036 (DCE 5) and 2270002072 (DCE 25)
- Run #2: 2270002036 (DCE 18)
- Run #3: 2270002072 (DCE 18)
- Run #4: 2270005015 (DCE 0)

ERG also verified that TexN2 still inserted the appropriate alternate scrappage curve into the CDBs of the newly isolated runs for diesel skid steer loaders and agricultural tractors.

Finally, ERG evaluated output nitrogen oxide (NO_x) emissions from the Microsoft Excel reports (detail by SCC) from the test case run. Table 2 summarizes the three versions of the test runs. Both the number of test runs (listed above) and the emissions results below confirmed the new code is working as intended. The tons per day (TPD) of NO_x subtotaled over the 3-run approach "Before" matches exactly with the "After" results by SCC.

Table 2. Test Case NO_x Emissions (Ton/Day) to Validate Utility Changes

	Before					After	Differences
	Single JSON	Three Split JSONs				Single JSON	(TPD)
SCC	All SCCs/DCEs	*Ag. Tractors*	*Skid Steers*	*Everything Else*	Subtotal	All SCCs/DCEs	
2270002036	0.0153	-	-	*0.0153*	0.0153	0.0153	0.000000
2270002072	1.3070	-	*1.2806*	*0.0796*	1.3602	1.3602	0.000000
2270005015	0.0780	*0.0975*	-	-	0.0975	0.0975	0.000000
Total	**1.4003**				**1.4730**	**1.4730**	**0.000000**

IV. QUALITY ASSURANCE

QA associated with MOVES3 Updates

The purpose of benchmark runs with the updated version of TexN2 was to ensure that no unintended changes were introduced into the source code that affect emissions. Through separate conversation with US EPA, ERG learned that MOVES3 contains no changes to the underlying code or data that affects nonroad (except for diesel sulfur values). Therefore, ERG expected TexN2.2 with MOVES3 to produce identical results as TexN2.1 with MOVES2014b.

The scope of the benchmark runs for QA covered a broad range of use cases of TexN2, including (1) fully controlled runs, (2) fully uncontrolled runs (i.e., no emissions controls), (3) automated Reasonable Further Progress (RFP) analyses, and (4) generating MOVES county databases (CDBs) for the NEI.

The benchmark runs focused on calendar year 2020 and included both ozone season day (OSD) weekday emissions in TPD and annual emissions in tons per year (TPY). The geographic scope covered eight counties in the Houston-Galveston-Brazoria (HGB) area and ten counties in the Dallas-Fort Worth (DFW) area. The annual and RFP runs focused on just two counties – Harris and Tarrant. Each benchmark run 1 through 5 required three separate runs to ensure use of the alternative scrappage curves for diesel agricultural tractors and diesel skid steer loaders, separately from all other nonroad categories which use the MOVES default scrappage curve because these runs were performed on the results of Task 3 before alternative scrappage curve code changes were implemented. QA of the scrappage curve changes can be found in Section IV B.

Benchmark No. 1 of 6

The first benchmark run compared emission outputs from TexN2.1 and TexN2.2 in 18 counties for a calendar year 2020 OSD weekday "fully controlled" EI. This run type is set up by checking the boxes "Texas Low Emission Diesel (TxLED)," "Reformulated gasoline," and "Enable all rules" in the Controls tab of the TexN2 GUI (Figure 5) and selecting the "Run all steps" button in the Run tab (Figure 6).

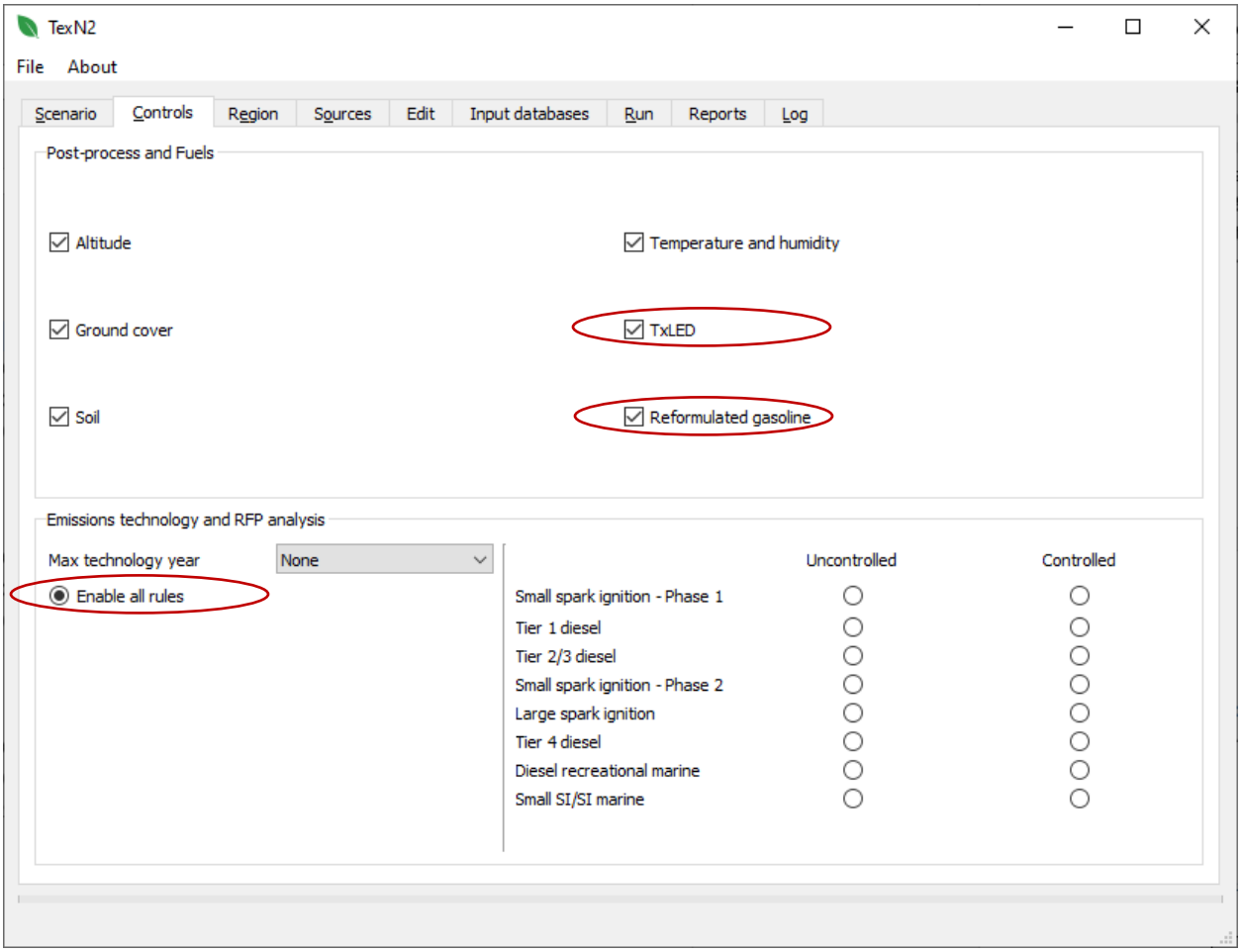


Figure 5. Control Tab settings for a Fully Controlled Scenario

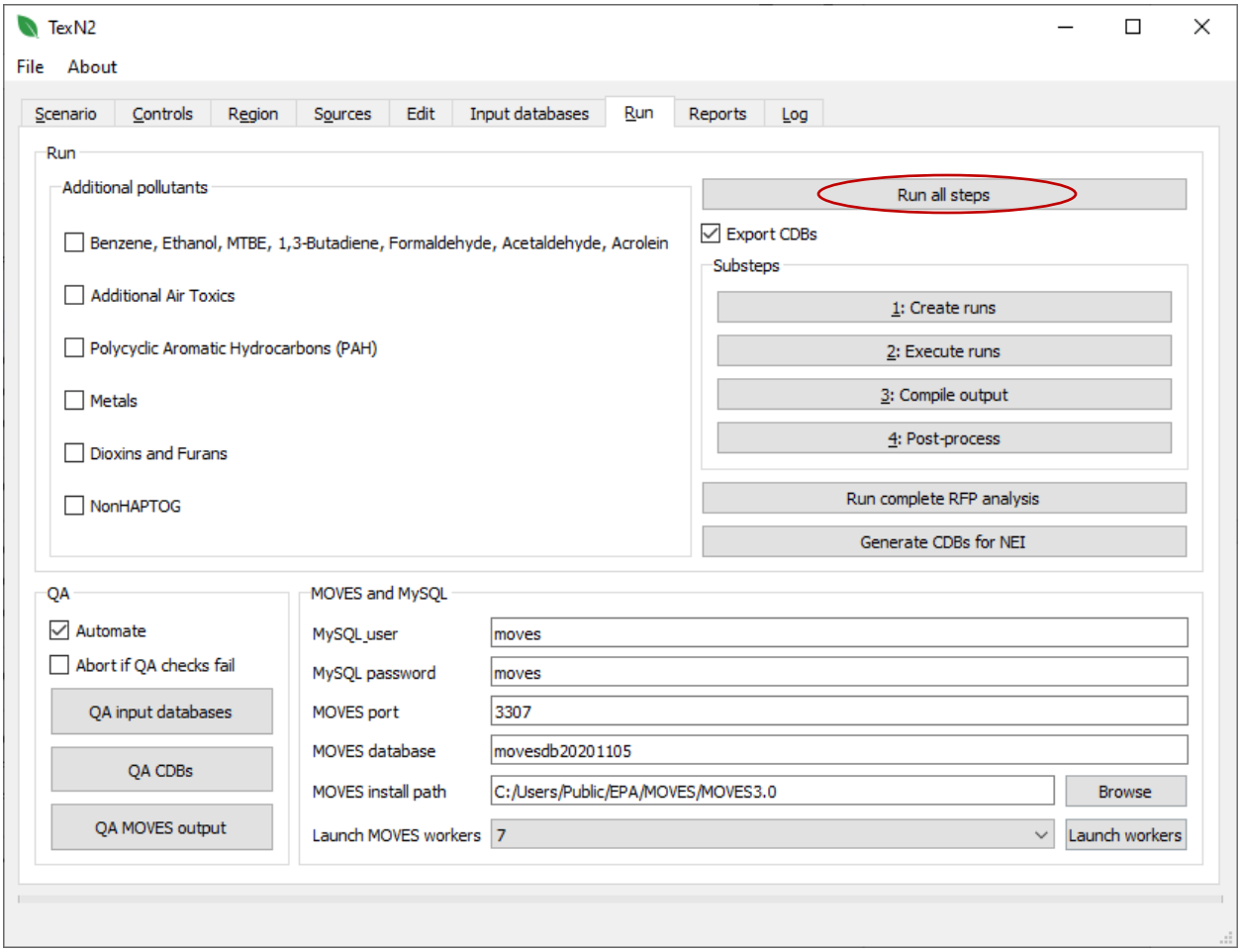


Figure 6. Run Tab selections for a Fully Controlled/Uncontrolled Scenario

The "Run all steps" selection in the Run tab is the procedure for developing any inventory other than an RFP analysis, and the action initiates sub steps 1 through 4 without further user intervention required. After the run completed, ERG exported the full suite of reports available from the Reports tab of the GUI.

Tables 3 through 5 show the emissions results for the Baseline (TexN2.1 with MOVES2014b) and the Scenario (TexN2.2 with MOVES3), with separate tables by pollutant NO_x, Volatile Organic Compounds (VOC), and Particulate Matter less than 10 microns (PM_{10}). All emissions units are TPD rounded to two decimal places, and the difference column represents Scenario minus Baseline to eight decimal places. Only small rounding differences in VOC are visible (Table 4).

Table 3. Differences in NO_x, 2020 OSD Weekday, Fully Controlled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline NO_x (TPD)	Scenario NO_x (TPD)	Difference NO_x (TPD)
48039	Brazoria County	2.37	2.37	0.00000000
48071	Chambers County	0.55	0.55	0.00000000
48085	Collin County	5.40	5.40	0.00000000
48113	Dallas County	13.22	13.22	0.00000000
48121	Denton County	3.53	3.53	0.00000000
48139	Ellis County	1.72	1.72	0.00000000
48157	Fort Bend County	2.92	2.92	0.00000000
48167	Galveston County	1.59	1.59	0.00000000
48201	Harris County	20.30	20.30	0.00000000
48251	Johnson County	1.39	1.39	0.00000000
48257	Kaufman County	1.61	1.61	0.00000000
48291	Liberty County	0.84	0.84	0.00000000
48339	Montgomery County	2.45	2.45	0.00000000
48367	Parker County	1.04	1.04	0.00000000
48397	Rockwall County	0.71	0.71	0.00000000
48439	Tarrant County	7.32	7.32	0.00000000
48473	Waller County	0.67	0.67	0.00000000
48497	Wise County	0.95	0.95	0.00000000
	Total	***68.59***	***68.59***	***0.00000000***

Table 4. Differences in VOC, 2020 OSD Weekday, Fully Controlled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline VOC (TPD)	Scenario VOC (TPD)	Difference VOC (TPD)
48039	Brazoria County	1.71	1.71	-0.00000003
48071	Chambers County	0.49	0.49	-0.00000002
48085	Collin County	3.82	3.82	0.00000002
48113	Dallas County	11.59	11.59	0.00000017
48121	Denton County	2.26	2.26	-0.00000004
48139	Ellis County	0.75	0.75	0.00000001
48157	Fort Bend County	1.94	1.94	0.00000000
48167	Galveston County	1.90	1.90	-0.00000010
48201	Harris County	16.33	16.33	0.00000001
48251	Johnson County	0.63	0.63	0.00000000
48257	Kaufman County	0.69	0.69	-0.00000001
48291	Liberty County	0.43	0.43	-0.00000001
48339	Montgomery County	2.30	2.30	-0.00000010

County ID	County Name	Baseline VOC (TPD)	Scenario VOC (TPD)	Difference VOC (TPD)
48367	Parker County	0.54	0.54	0.00000001
48397	Rockwall County	0.57	0.57	-0.00000001
48439	Tarrant County	6.04	6.04	0.00000023
48473	Waller County	0.36	0.36	0.00000000
48497	Wise County	0.46	0.46	-0.00000002
	Total	***52.81***	***52.81***	***0.00000011***

Table 5. Differences in PM_{10}, 2020 OSD Weekday, Fully Controlled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline PM_{10} (TPD)	Scenario PM_{10} (TPD)	Difference PM_{10} (TPD)
48039	Brazoria County	0.24	0.24	0.00000000
48071	Chambers County	0.05	0.05	0.00000000
48085	Collin County	0.58	0.58	0.00000000
48113	Dallas County	1.48	1.48	0.00000000
48121	Denton County	0.33	0.33	0.00000000
48139	Ellis County	0.15	0.15	0.00000000
48157	Fort Bend County	0.31	0.31	0.00000000
48167	Galveston County	0.17	0.17	0.00000000
48201	Harris County	2.19	2.19	0.00000000
48251	Johnson County	0.13	0.13	0.00000000
48257	Kaufman County	0.16	0.16	0.00000000
48291	Liberty County	0.08	0.08	0.00000000
48339	Montgomery County	0.29	0.29	0.00000000
48367	Parker County	0.11	0.11	0.00000000
48397	Rockwall County	0.08	0.08	0.00000000
48439	Tarrant County	0.78	0.78	0.00000000
48473	Waller County	0.07	0.07	0.00000000
48497	Wise County	0.09	0.09	0.00000000
	Total	***7.30***	***7.30***	***0.00000000***

Benchmark No. 2 of 6

The second benchmark run was similar to the first except it was annual instead of OSD and covered only Harris and Tarrant Counties. The selections in the Controls and Run tab were identical to benchmark run 1. Table 6 shows the NO_X, VOC, and PM_{10} results, with only small rounding differences visible in the NO_X and VOC comparisons.

Table 6. Differences in NO_X, VOC, and PM_{10}; 2020 Annual; Fully Controlled; Harris and Tarrant Counties

County ID	County Name	Baseline (TPY)	Scenario (TPY)	Difference (TPY)
NO_X				
48201	Harris County	6,136.81	6,136.81	0.00016375
48439	Tarrant County	2,222.35	2,222.35	0.00012355
	Total NO_X	***8,359.16***	***8,359.16***	***0.00028730***
VOC				
48201	Harris County	5,141.83	5,141.83	-0.00023071
48439	Tarrant County	1,833.65	1,833.65	-0.00015187
	Total VOC	***6,975.49***	***6,975.49***	***-0.00038258***
PM_{10}				
48201	Harris County	626.66	626.66	0.00000000
48439	Tarrant County	222.43	222.43	0.00000000
	Total PM_{10}	***849.09***	***849.09***	***0.00000000***

Benchmark No. 3 of 6

The third benchmark run compared emission outputs from TexN2.1 and TexN2.2 in 18 counties for a calendar year 2020 OSD weekday "fully uncontrolled" EI. All emission controls can be turned off using the Controls tab of the GUI by unchecking "TxLED" and "Reformulated Gasoline," and checking the "Uncontrolled" radio button adjacent to Small spark ignition – Phase 1, as shown in Figure 7.

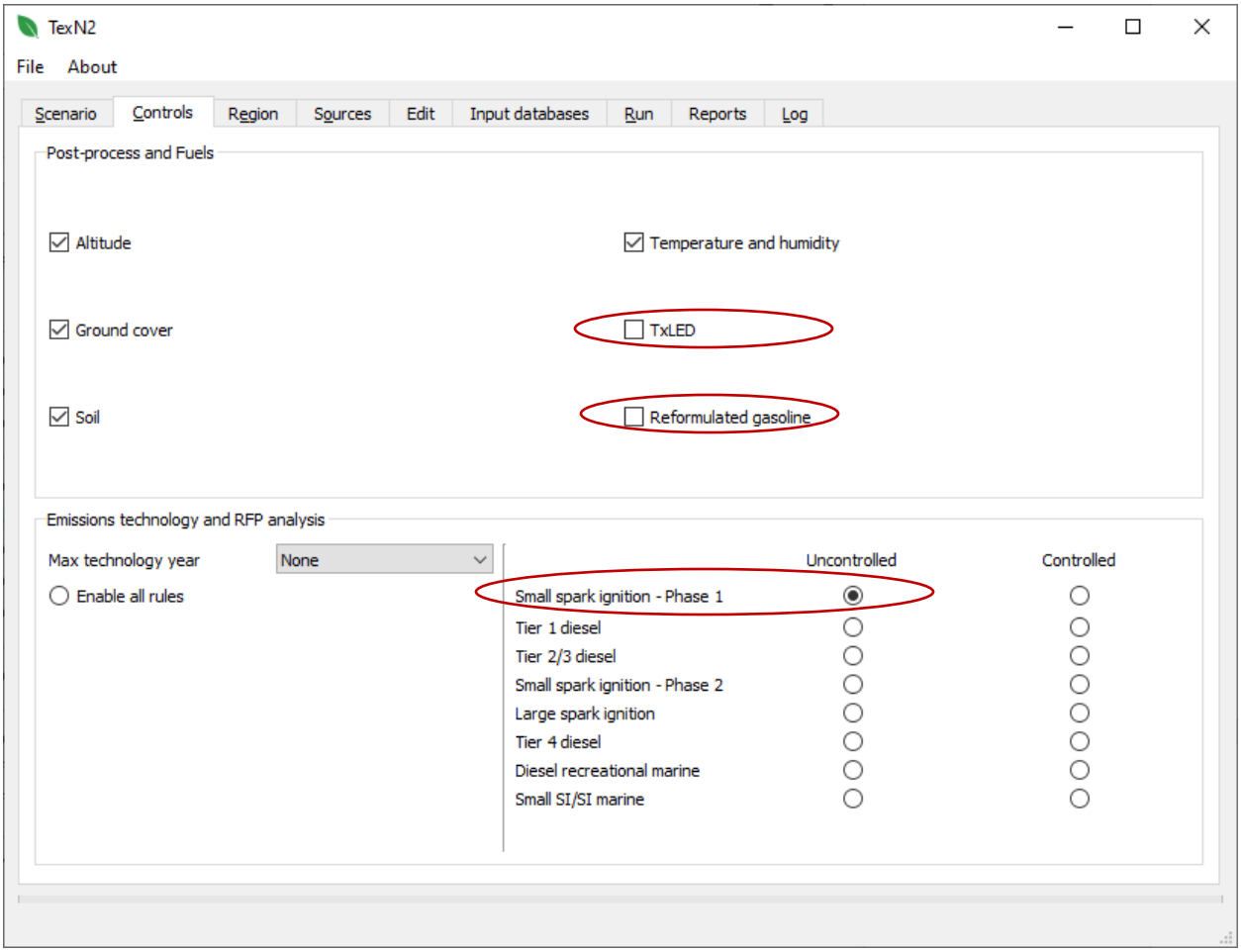


Figure 7. Control Tab settings for a Fully Uncontrolled Scenario

The "Run all steps" selection in the Run tab (shown previously in Figure 6) was used to launch the fully uncontrolled runs. ERG then exported the emissions using the Reports tab of the GUI. Tables 7 through 9 show the emissions results for the Baseline (TexN2.1 with MOVES2014b) and the Scenario (TexN2.2 with MOVES3), with separate tables by pollutant NO_x, VOC, and PM_{10}. Only small rounding differences in VOC are visible (Table 8).

Table 7. Differences in NO_x, 2020 OSD Weekday, Fully Uncontrolled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline NO_x (TPD)	Scenario NO_x (TPD)	Difference NO_x (TPD)
48039	Brazoria County	13.75	13.75	0.00000000
48071	Chambers County	3.63	3.63	0.00000000
48085	Collin County	28.71	28.71	0.00000000
48113	Dallas County	57.87	57.87	0.00000000
48121	Denton County	17.22	17.22	0.00000000

County ID	County Name	Baseline NO_X (TPD)	Scenario NO_X (TPD)	Difference NO_X (TPD)
48139	Ellis County	9.17	9.17	0.00000000
48157	Fort Bend County	18.84	18.84	0.00000000
48167	Galveston County	6.07	6.07	0.00000000
48201	Harris County	97.27	97.27	0.00000000
48251	Johnson County	8.76	8.76	0.00000000
48257	Kaufman County	9.38	9.38	0.00000000
48291	Liberty County	6.28	6.28	0.00000000
48339	Montgomery County	10.62	10.62	0.00000000
48367	Parker County	5.73	5.73	0.00000000
48397	Rockwall County	3.41	3.41	0.00000000
48439	Tarrant County	32.83	32.83	0.00000000
48473	Waller County	4.78	4.78	0.00000000
48497	Wise County	6.32	6.32	0.00000000
	Total	***340.64***	***340.64***	***0.00000000***

Table 8. Differences in VOC, 2020 OSD Weekday, Fully Uncontrolled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline VOC (TPD)	Scenario VOC (TPD)	Difference VOC (TPD)
48039	Brazoria County	11.96	11.96	0.00000001
48071	Chambers County	3.35	3.35	0.00000000
48085	Collin County	26.80	26.80	0.00000019
48113	Dallas County	62.66	62.66	0.00000048
48121	Denton County	14.08	14.08	-0.00000003
48139	Ellis County	5.17	5.17	0.00000003
48157	Fort Bend County	16.46	16.46	-0.00000002
48167	Galveston County	8.07	8.07	0.00000000
48201	Harris County	87.04	87.04	0.00000018
48251	Johnson County	6.28	6.28	0.00000000
48257	Kaufman County	6.28	6.28	-0.00000001
48291	Liberty County	4.36	4.36	-0.00000001
48339	Montgomery County	10.70	10.70	-0.00000010
48367	Parker County	3.82	3.82	0.00000001
48397	Rockwall County	3.29	3.29	0.00000002
48439	Tarrant County	32.67	32.67	0.00000015
48473	Waller County	3.84	3.84	0.00000000
48497	Wise County	3.85	3.85	-0.00000001
	Total	***310.67***	***310.67***	***0.00000088***

Table 9. Differences in PM_{10}, 2020 OSD Weekday, Fully Uncontrolled, 18 Counties in the HGB and DFW Areas

County ID	County Name	Baseline PM_{10} (TPD)	Scenario PM_{10} (TPD)	Difference PM_{10} (TPD)
48039	Brazoria County	0.74	0.74	0.00000000
48071	Chambers County	0.12	0.12	0.00000000
48085	Collin County	1.68	1.68	0.00000000
48113	Dallas County	5.17	5.17	0.00000000
48121	Denton County	1.47	1.47	0.00000000
48139	Ellis County	0.52	0.52	0.00000000
48157	Fort Bend County	0.89	0.89	0.00000000
48167	Galveston County	0.59	0.59	0.00000000
48201	Harris County	8.34	8.34	0.00000000
48251	Johnson County	0.43	0.43	0.00000000
48257	Kaufman County	0.51	0.51	0.00000000
48291	Liberty County	0.24	0.24	0.00000000
48339	Montgomery County	1.08	1.08	0.00000000
48367	Parker County	0.39	0.39	0.00000000
48397	Rockwall County	0.27	0.27	0.00000000
48439	Tarrant County	2.68	2.68	0.00000000
48473	Waller County	0.16	0.16	0.00000000
48497	Wise County	0.32	0.32	0.00000000
	Total	***25.61***	***25.61***	***0.00000000***

Benchmark No. 4 of 6

The fourth benchmark run was similar to the third (fully uncontrolled) except it was annual and covered only Harris and Tarrant Counties. The selections in the Controls tab were identical to benchmark run 3. Table 10 shows the NO_X, VOC, and PM_{10} results, with only small rounding differences visible in the VOC comparisons.

Table 10. Differences in NO_X, VOC, and PM_{10}; 2020 Annual; Fully Uncontrolled; Harris and Tarrant Counties

County ID	County Name	Baseline (TPY)	Scenario (TPY)	Difference (TPY)
NO_X				
48201	Harris County	28,375.14	28,375.14	0.00000000
48439	Tarrant County	9,597.01	9,597.01	0.00000000
	Total NO_X	37,972.14	37,972.14	0.00000000
VOC				
48201	Harris County	26,463	26,463	-0.00012902
48439	Tarrant County	9,702	9,702	-0.00001209

County ID	County Name	Baseline (TPY)	Scenario (TPY)	Difference (TPY)
	Total VOC	36,165	36,165	-0.00014111
PM_{10}				
48201	Harris County	2,322.22	2,322.22	0.00000000
48439	Tarrant County	762.02	762.02	0.00000000
	Total PM_{10}	3,084.24	3,084.24	0.00000000

Benchmark No. 5 of 6

The fifth benchmark run compared emission outputs from an automated RFP analysis in 2 counties (Harris and Tarrant) for a calendar year 2020 OSD weekday. An RFP analysis generates the ten EI scenarios below.

RFP Scenario Name	Description
1. smallSprk1_uncntl	No controls
2. smallSprk1_cntl	Controls through Small nonroad spark ignition (SI) engines (Phase 1)
3. Tier1_cntl	Controls through Tier 1 nonroad diesel engines
4. Tier2_3_cntl	Controls through Tiers 2 and 3 nonroad diesel engines
5. smallSprk2_cntl	Controls through Small nonroad SI engines (Phase II)
6. largeSprk_cntl	Controls through Large nonroad SI engines
7. Tier4_cntl	Controls through Tier 4 nonroad diesel engines
8. recMarine_cntl	Controls through Diesel recreational marine engines
9. smallSI_cntl	Controls through SI marine engines
10. allRules_cntl	Controls through SI marine engines, plus RFG and TxLED fuel controls

Tables 11 through 13 show agreement in all RFP scenarios for NO_x, VOC, and PM_{10}.

Note that Table 11 shows small NO_x increases going from the No Controls scenario (smallSprk1_unctl) to the first control scenario for Small Nonroad SI Engines Phase I (smallsprk1_cntl). The small NO_x increase was allowed under the small SI rule, where some equipment have their standards defined in terms of hydrocarbon (HC) combined with NO_x. That rule is aimed at lowering HC emissions, and slight increases in NO_x are allowed so long as the HC goes down substantially. Table 12 shows the VOC decreasing significantly between the first two RFP scenarios.

Table 11. Differences in NO_X, 2020 OSD Weekday, Automated RFP Scenarios, Harris and Tarrant Counties

RFP Scenario Name	Baseline NO_X (TPD)	Scenario NO_X (TPD)	Difference NO_X (TPD)
County ID = 48201 Harris County			
1. smallSprk1_uncntl	97.27	97.27	0.00000351
2. smallSprk1_cntl	100.01	100.01	0.00000486
3. Tier1_cntl	99.47	99.47	0.00000495
4. Tier2_3_cntl	97.07	97.07	0.00000495
5. smallSprk2_cntl	95.16	95.16	0.00000420
6. largeSprk_cntl	62.19	62.19	0.00000292
7. Tier4_cntl	22.82	22.82	0.00000292
8. recMarine_cntl	22.82	22.82	0.00000292
9. smallSI_cntl	21.04	21.04	0.00000132
10. allRules_cntl	20.30	20.30	0.00000152
County ID = 48439 Tarrant County			
1. smallSprk1_uncntl	32.83	32.83	0.00000160
2. smallSprk1_cntl	33.86	33.86	0.00000217
3. Tier1_cntl	33.57	33.57	0.00000218
4. Tier2_3_cntl	32.72	32.72	0.00000218
5. smallSprk2_cntl	32.00	32.00	0.00000181
6. largeSprk_cntl	19.68	19.68	0.00000093
7. Tier4_cntl	8.21	8.21	0.00000093
8. recMarine_cntl	8.21	8.21	0.00000093
9. smallSI_cntl	7.57	7.57	0.00000048
10. allRules_cntl	7.32	7.32	0.00000065

Table 12. Differences in VOC, 2020 OSD Weekday, Automated RFP Scenarios, Harris and Tarrant Counties

RFP Scenario Name	Baseline VOC (TPD)	Scenario VOC (TPD)	Difference VOC (TPD)
County ID = 48201 Harris County			
1. smallSprk1_uncntl	87.04	87.04	-0.00001113
2. smallSprk1_cntl	66.21	66.21	-0.00000718
3. Tier1_cntl	64.53	64.53	-0.00000713
4. Tier2_3_cntl	64.07	64.07	-0.00000713
5. smallSprk2_cntl	45.45	45.45	-0.00000326
6. largeSprk_cntl	34.23	34.23	-0.00000274
7. Tier4_cntl	25.56	25.56	-0.00000274
8. recMarine_cntl	25.56	25.56	-0.00000287
9. smallSI_cntl	16.44	16.44	-0.00000238

RFP Scenario Name	Baseline VOC (TPD)	Scenario VOC (TPD)	Difference VOC (TPD)
10. allRules_cntl	16.33	16.33	-0.00000213
County ID = 48439 Tarrant County			
1. smallSprk1_uncntl	32.67	32.67	-0.00000269
2. smallSprk1_cntl	24.66	24.66	-0.00000158
3. Tier1_cntl	24.43	24.43	-0.00000158
4. Tier2_3_cntl	24.28	24.28	-0.00000158
5. smallSprk2_cntl	17.04	17.04	-0.00000114
6. largeSprk_cntl	12.41	12.41	-0.00000104
7. Tier4_cntl	9.68	9.68	-0.00000104
8. recMarine_cntl	9.68	9.68	-0.00000106
9. smallSI_cntl	6.16	6.16	-0.00000044
10. allRules_cntl	6.04	6.04	-0.00000046

Table 13. Differences in PM_{10}, 2020 OSD Weekday, Automated RFP Scenarios, Harris and Tarrant Counties

RFP Scenario Name	Baseline PM_{10} (TPD)	Scenario PM_{10} (TPD)	Difference PM_{10} (TPD)
County ID = 48201 Harris County			
1. smallSprk1_uncntl	8.34	8.34	0.00000000
2. smallSprk1_cntl	8.26	8.26	0.00000000
3. Tier1_cntl	8.12	8.12	0.00000000
4. Tier2_3_cntl	7.80	7.80	0.00000000
5. smallSprk2_cntl	7.72	7.72	0.00000000
6. largeSprk_cntl	7.70	7.70	0.00000000
7. Tier4_cntl	2.23	2.23	0.00000000
8. recMarine_cntl	2.23	2.23	0.00000000
9. smallSI_cntl	2.19	2.19	0.00000000
10. allRules_cntl	2.19	2.19	0.00000000
County ID = 48439 Tarrant County			
1. smallSprk1_uncntl	2.68	2.68	0.00000000
2. smallSprk1_cntl	2.65	2.65	0.00000000
3. Tier1_cntl	2.60	2.60	0.00000000
4. Tier2_3_cntl	2.50	2.50	0.00000000
5. smallSprk2_cntl	2.47	2.47	0.00000000
6. largeSprk_cntl	2.47	2.47	0.00000000
7. Tier4_cntl	0.79	0.79	0.00000000
8. recMarine_cntl	0.79	0.79	0.00000000
9. smallSI_cntl	0.78	0.78	0.00000000
10. allRules_cntl	0.78	0.78	0.00000000

Benchmark No. 6 of 6

The sixth benchmark run created MOVES CDBs from the GUI's Run tab "Generate CDBs for NEI" button (Figure 8). The scope included all 18 counties in HGB and DFW area for the next NEI year, 2020. As described previously, US EPA requires a single CDB per county. Because TexN2 runs multiple CDBs per county, TexN2 needs to aggregate across DCE subsectors to arrive at average hours/year activity and total population in the aggregated CDBs to meet the NEI requirements.

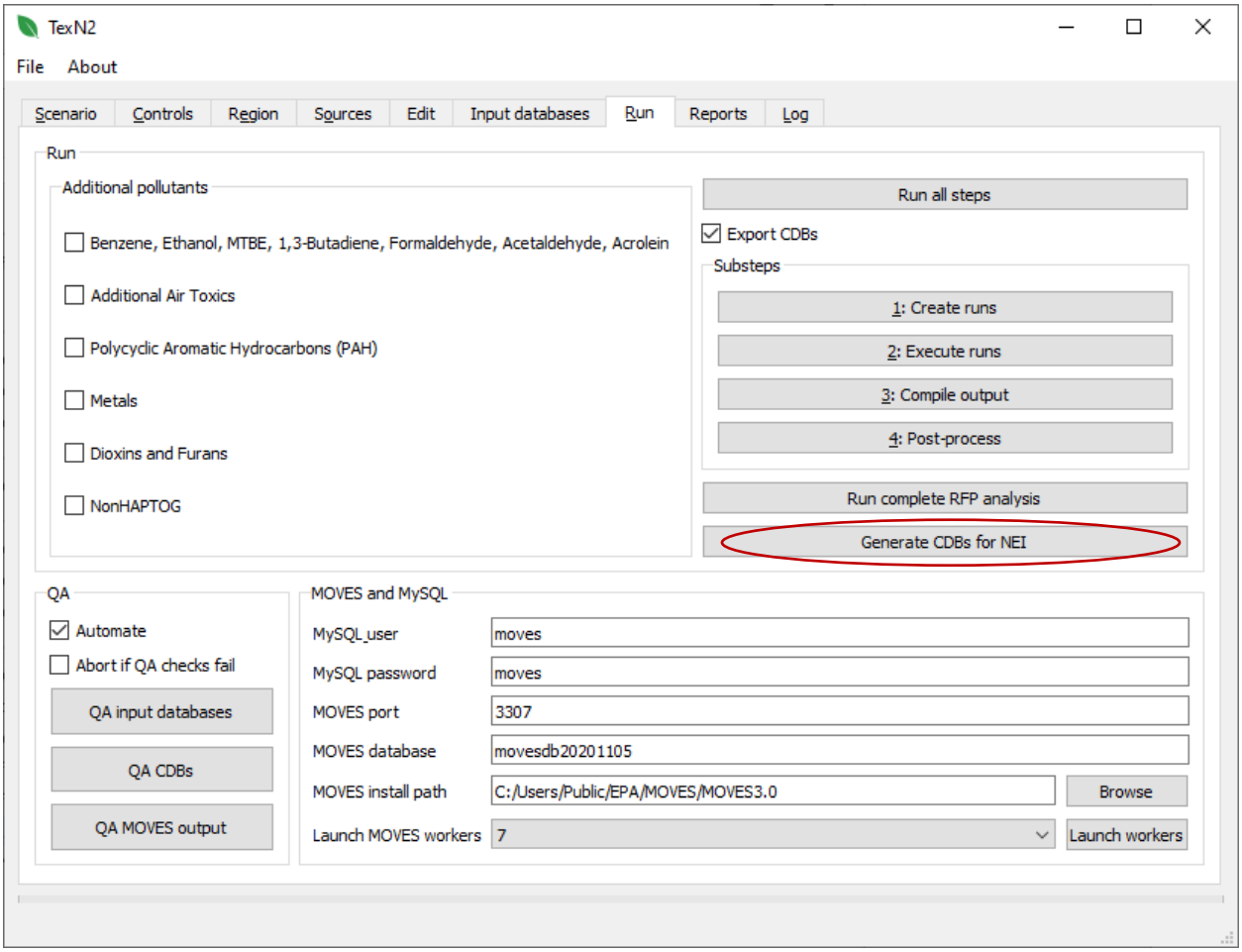


Figure 8. Run Tab showing the "Generate CDBs for NEI" Launch Button

For the QA of benchmark run 6, ERG evaluated each CDB table against the corresponding TexN2 database tables to ensure the CDB was correctly populated, incorporating data from TexN2 as intended and MOVES3 where appropriate. Unlike benchmark runs 1 through 5, comparison of TexN2.2 NEI CDBs with the prior TexN2.1 utility is not appropriate for the NEI CDBs due to major updates in July 2020 to the TexN2 database that changed population, activity, and load factors (ERG, 2020).

Table 14 lists the thirteen MOVES tables TexN2 creates for each CDB via the "Generate CDBs for NEI" function, the CDB table's data source, and whether the CDB table will be

used by EPA in the NEI. All tables except fuels and meteorology in Table 14 will be inputs for the NEI.

Table 14. MOVES CDB Tables, Data Source(s), and Use for the NEI

TexN2-Prepared MOVES CDB Table Name	Data Source(s)	Notes for NEI Use
1. County	MOVES3 database `county` table and TexN2 database `atmpressure` table	Local data (barometric pressure) will be used in the NEI.
2. CountyYear	MOVES3 `countyyear` table with a TexN2 update to disable Stage II refueling controls.	Local data (disabling Stage II controls) will be used in the NEI.
3. FuelFormulation	TexN2 `fuels` table	Not needed. EPA uses their own refinery gate data.
4. NRBaseYearEquipPopulation	TexN2 `populationyears` table	Local data (population) will be used in the NEI.
5. NRDayAllocation	TexN2 `NRDayAllocation` table	Local data (day type allocation of activity) will be used in the NEI
6. NREquipmentType	MOVES3 `NREquipmentType' table with default surrogates disabled & new one added for TX to allocate 100% state population to the county.	Local data (overriding default state-to-county allocation factors) will be used in the NEI.
7. NRFuelSupply	TexN2 `fuels` table	Not needed. EPA uses their own refinery gate data.
8. NRMonthAllocation	TexN2 `NRMonthAllocation` table	Local data (month allocation of activity) will be used in the NEI.
9. NRSCC	TexN2 `sccs` table with updated NREquipTypeID to match the CDB `NREquipmentType` table.	Will be used in NEI.
10. NRSourceUseType	TexN2 `activity` and `populationmain` tables.	Local data (hours of operation, LF, etc.) will be used for NEI.
11. NRStateSurrogate	TexN2 overrides the default state-to-county geographic allocation factors.	Local data supplied at county level will be used for NEI.
12. NRSurrogate	TexN2 adds a new Texas surrogate ID (20) to the MOVES3 `NRSurrogate` table.	Alternative surrogate will be used for NEI.
13. ZoneMonthHour	TexN2 database `climate` table	Not needed. EPA uses their own meteorology data.

Benchmark run 6 passed all QA checks:

- The CDB `county` table barometricPressure matches the TexN2 `atmpressure` table with a unit conversion from millibars to inches Hg.
- The CDB `countyyear` table successfully turns off Stage II controls by setting the refuelingVaporProgramAdjust value (program efficiency) to zero.
- The CDB `nrbaseyearequippopulation` table correctly transfers nonroad equipment populations from the TexN2 `populationyears` table (see Table 15)
- The CDB `nrdayallocation` table matches the TexN2 `nrdayallocation` table.
- The CDB `nrequipmentype` table successfully adds an alternative surrogate ID specific to Texas, to allocate of 100% of the state population to the county.
- The CDB `nrmonthallocation` table matches the TexN2 `nrmonthallocation` table.
- The CDB `nrscc` table matches the MOVES3 SCC list with updated crosswalk NREquipTypeIDs to be consistent with other CDB tables that use the Texas surrogate.
- The CDB `nrsourceusetype` table is consistent with the TexN2 `activity` and `populationmain` tables. ERG performed a spot check on the hours/year activity by HP bin for Excavators and reproduced the population-weighted activity from an aggregation across DCE subsector for SCC 2270002036.
- The CDB `nrstatesurrogate` and `nrsurrogate` tables coordinate correctly with the CDB `nrequipmenttype` table.
- The CDB tables `fuelformulation`, `nrfuelsupply`, and `zonemonthhour` are not used in the NEI, and therefore were not reviewed.

Table 15. MOVES CDB Population QA Check

CDB Name	CDB table totals from `NRBaseYearEquipPopulation`	TexN2 totals from `populationyears` and `populationmain`	Difference
c48039y2020_nr_20210221	114,981.21	114,981.21	0.00001288
c48071y2020_nr_20210221	20,110.20	20,110.20	0.00000074
c48085y2020_nr_20210221	258,841.10	258,841.10	-0.00005355
c48113y2020_nr_20210221	1,017,036.67	1,017,036.67	0.00019663
c48121y2020_nr_20210221	204,094.11	204,094.11	-0.00001332
c48139y2020_nr_20210221	52,828.23	52,828.23	0.00000939
c48157y2020_nr_20210221	139,316.42	139,316.42	-0.00001874
c48167y2020_nr_20210221	142,826.66	142,826.66	-0.00001844
c48201y2020_nr_20210221	1,539,961.03	1,539,961.03	0.00015149
c48251y2020_nr_20210221	50,164.52	50,164.52	-0.00000740
c48257y2020_nr_20210221	34,631.68	34,631.68	0.00000708
c48291y2020_nr_20210221	29,029.76	29,029.76	0.00000079
c48339y2020_nr_20210221	155,050.00	155,050.00	-0.00000711

CDB Name	CDB table totals from `NRBaseYearEquipPopulation`	TexN2 totals from `populationyears` and `populationmain`	Difference
c48367y2020_nr_20210221	39,148.30	39,148.30	-0.00000908
c48397y2020_nr_20210221	26,811.33	26,811.33	-0.00001130
c48439y2020_nr_20210221	638,119.39	638,119.39	-0.00000802
c48473y2020_nr_20210221	15,780.55	15,780.55	-0.00000081
c48497y2020_nr_20210221	24,633.90	24,633.90	0.00000135

QA associated with the Scrappage Update

ERG performed additional QA runs to further ensure the new source code changes to address automating use of alternative scrappage curves was working as intended. The QA of these source code changes was a re-run of benchmark run 2. The expectation was that full (all source category) TexN2 runs following the scrappage updates should result in identical emissions from a single run compared to the prior code with a 3-split-run approach.

Table 16 shows the results of the scrappage update "After" compared to "Before" for a calendar year 2020, annual, fully controlled run in Harris and Tarrant counties. The total emissions of NO_x, VOC, and PM_{10} in units of tons per year (TPY) do not change.

Table 16. Differences in NO_x, VOC, and PM_{10}; 2020 Annual; Fully Controlled; Harris and Tarrant Counties

County ID	County Name	Before* TexN2.1-MOVES2014b (TPY)	Before* TexN2.2-MOVES3 (TPY)	After with Automated Alt. Scrappage (TPY)	Difference (TPY)
NO_x					
48201	Harris	6,136.81	6,136.81	6,136.81	0.00000000
48439	Tarrant	2,222.35	2,222.35	2,222.35	0.00000000
	Total NO_x	***8,359.16***	***8,359.16***	***8,359.16***	***0.00000000***
VOC					
48201	Harris	5,141.83	5,141.83	5,141.83	0.00000000
48439	Tarrant	1,833.65	1,833.65	1,833.65	0.00000000
	Total VOC	***6,975.49***	***6,975.49***	***6,975.49***	***0.00000000***
PM_{10}					
48201	Harris	626.66	626.66	626.66	0.00000000
48439	Tarrant	222.43	222.43	222.43	0.00000000
	Total PM_{10}	***849.09***	***849.09***	***849.09***	***0.00000000***

*Before results in Table 16 reflect a 3-split-run approach.

QA Audit

As documented separately in the Quality Assurance Project Plan, the TexN2 utility update project qualifies as Level III: Software Evaluation, Software Related Research, Software Maintenance, or Software Development. Level III QAPPs require a "ten percent" audit, which is partly met by the benchmark and QA runs in Sections IV A and B. This section adds eight counties to the QA comparisons in benchmark run 1 (Table 3). The 26 counties total presented in Table 17 comprises 10.2% of the 254 counties in Texas. The additional eight counties include rural counties to balance the urban county focus of 8-county HGB and 10-county DFW areas. The lower 18 counties are a repeat of the information already presented in Table 3. Only the top eight-county highlighted results are new.

Table 17. Differences in NO_x, 2020 OSD Weekday, Fully Controlled, 26 Counties covering a 10% Audit of Texas Counties

County ID	County Name	Baseline NO_X (TPD)	Scenario NO_X (TPD)	Difference NO_X (TPD)
48001	Anderson County	0.53	0.53	0.00000002
48003	Andrews County	0.40	0.40	0.00000000
48005	Angelina County	0.49	0.49	0.00000008
48007	Aransas County	0.25	0.25	0.00000013
48009	Archer County	1.48	1.48	-0.00000001
48011	Armstrong County	1.20	1.20	-0.00000001
48013	Atascosa County	0.68	0.68	0.00000002
48015	Austin County	0.72	0.72	0.00000001
48039	Brazoria County	2.37	2.37	0.00000000
48071	Chambers County	0.55	0.55	0.00000000
48085	Collin County	5.40	5.40	0.00000000
48113	Dallas County	13.22	13.22	0.00000000
48121	Denton County	3.53	3.53	0.00000000
48139	Ellis County	1.72	1.72	0.00000000
48157	Fort Bend County	2.92	2.92	0.00000000
48167	Galveston County	1.59	1.59	0.00000000
48201	Harris County	20.30	20.30	0.00000000
48251	Johnson County	1.39	1.39	0.00000000
48257	Kaufman County	1.61	1.61	0.00000000
48291	Liberty County	0.84	0.84	0.00000000
48339	Montgomery County	2.45	2.45	0.00000000
48367	Parker County	1.04	1.04	0.00000000
48397	Rockwall County	0.71	0.71	0.00000000
48439	Tarrant County	7.32	7.32	0.00000000
48473	Waller County	0.67	0.67	0.00000000
48497	Wise County	0.95	0.95	0.00000000
	Total	***74.34***	***74.34***	***0.00000023***

V. GETTING STARTED USING TEXN2.2

The information presented in this section is intended for TexN2 users who are familiar with the prior utility, TexN2.1 with MOVES2014b. ERG has included this same information in the User's Guide for TexN2.2.

To get started, users should perform the following actions in order:

1. Download and Unzip the TexN2.2 Utility

Download and unzip the utility TexN2_v2_2_0_*.zip to your local machine where * is the date. ERG provided this file electronically to the TCEQ. Unzip the package, and the top-level directory should show a "dist" directory and a file with a ".sql" extension.

C:\TexN2_v2_2_0_23apr21\dist
C:\TexN2_v2_2_0_23apr21\TexN2_23apr21.sql

2. Download and Install MOVES3

MOVES3 is available from the US EPA website https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

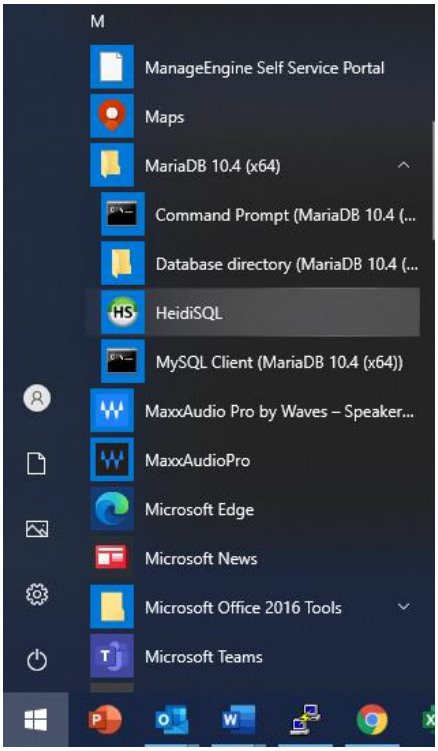
Note: The TexN2.2 utility requires MOVES3.0.0 or later. It will not run with prior versions of MOVES (i.e., MOVES2014b and earlier). At the time of writing, the latest version of MOVES is MOVES3.0.1.

Important: The US EPA installer for MOVES3 automatically installs MariaDB. During the MariaDB installation process, you will be asked to set a MariaDB root user password. Write this password down; it is not recoverable later. The root user password is needed in Step 3.

3. Configure the "moves" User

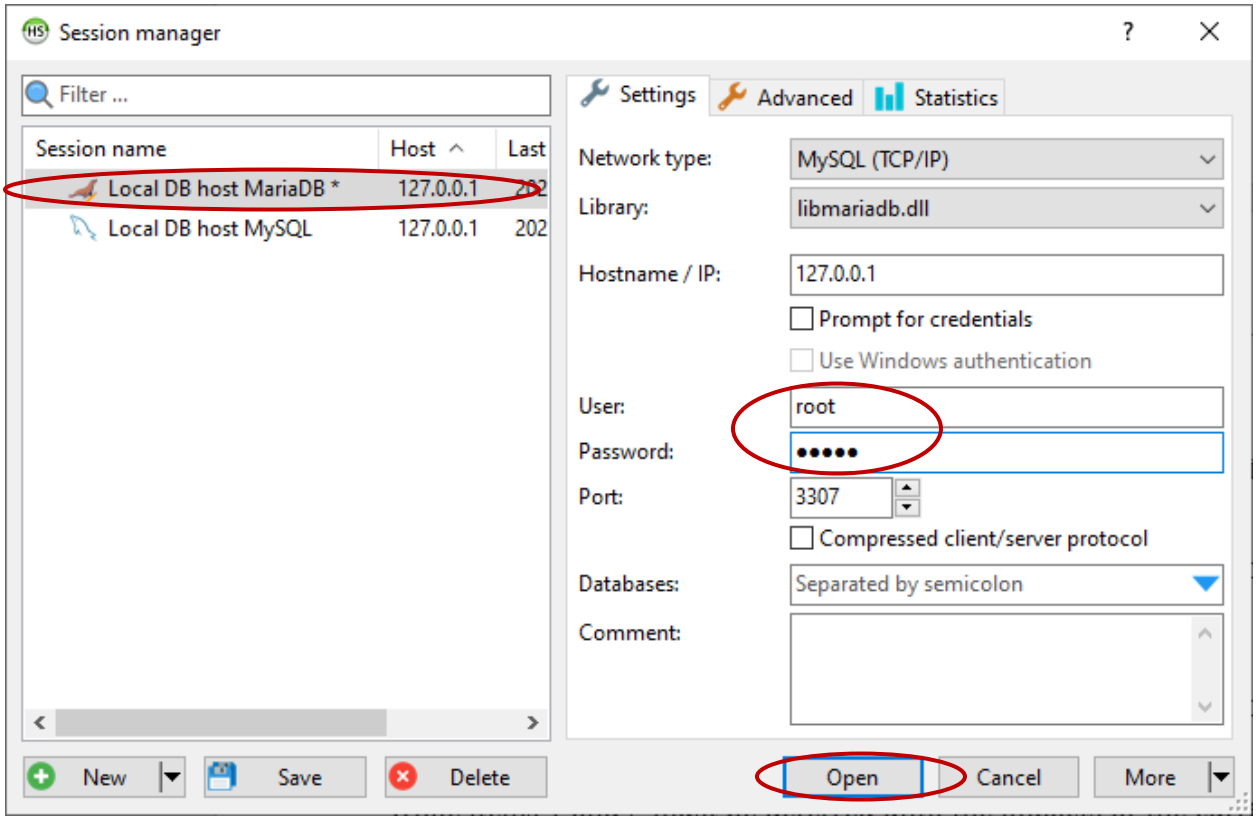
Open HeidiSQL from the start menu. HeidiSQL is a GUI for MariaDB provided with the MOVES3 package, analogous to MySQL Workbench for MySQL.

Launch HeidiSQL:

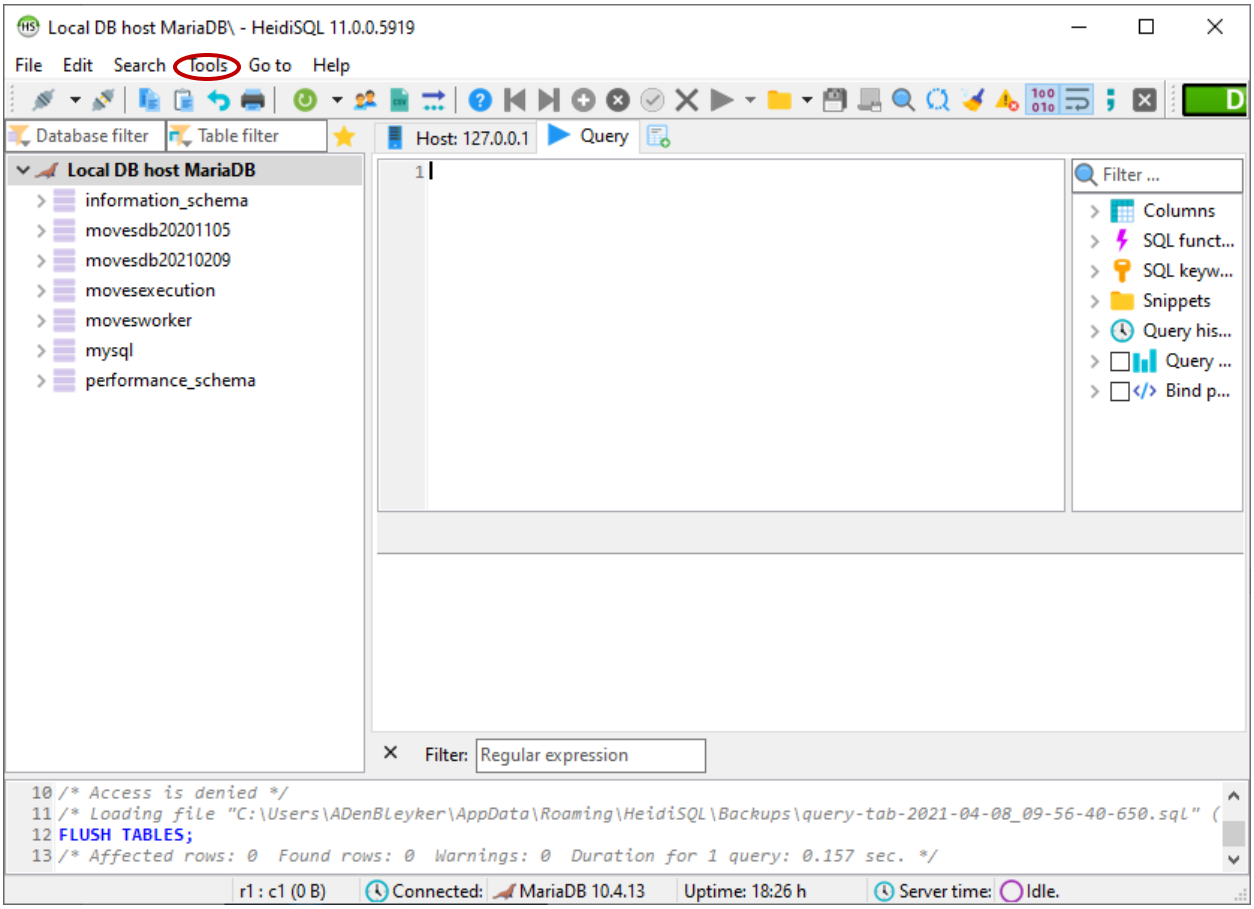


Click on a connection and log in. The MOVES3 installer should have set up a connection named "MOVES Connection" for the MariaDB port. In the image below, 3307 is the port number, but your port may be different.

> **Important**: For this particular log-in session, update the user to "root" and the root user password you set earlier during the MariaDB configuration during the MOVES3 installation.
>
> **Note:** the screenshot below has custom named connection set up "Local DB host MariaDB." Unless you already have custom connections setup, select the default "MOVES Connection", change the user to root, enter the password, then click Open.

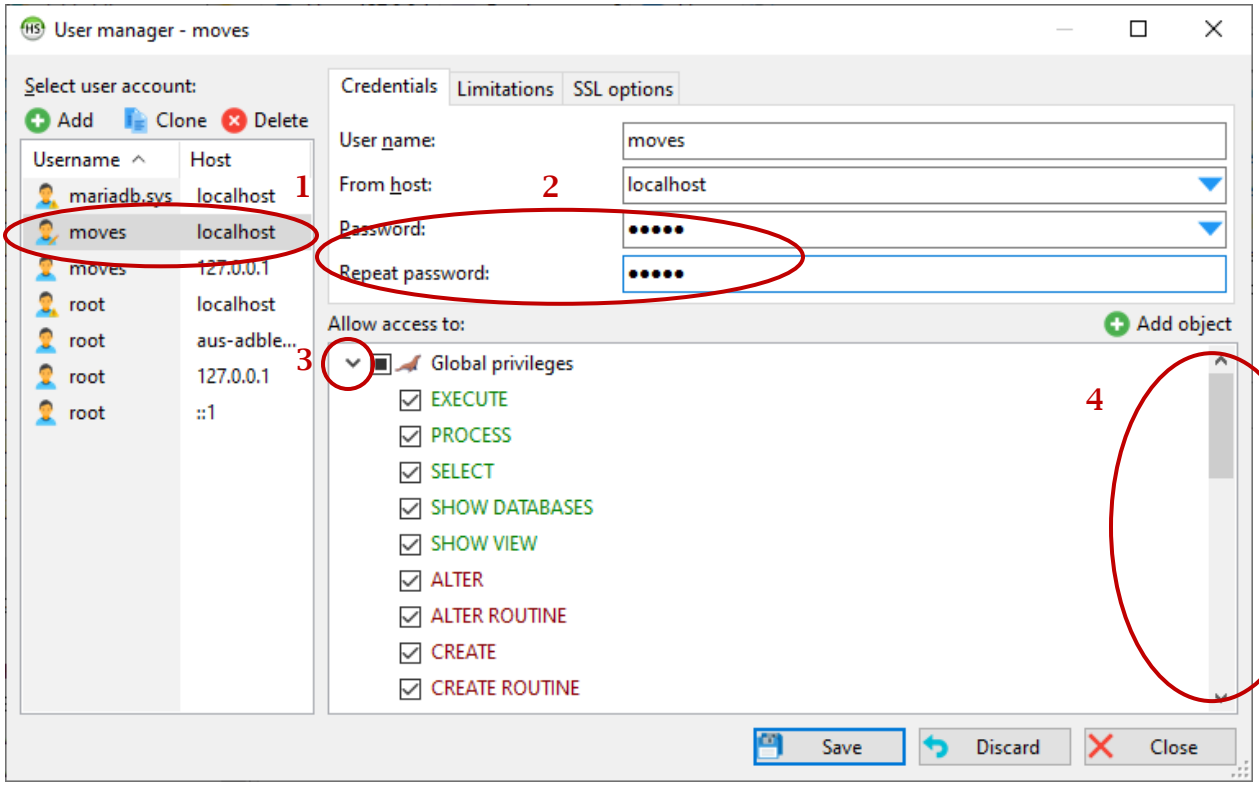


After logging in, you should see a screen similar to the image below. On the left are the MySQL databases currently on the machine and on the right is a workspace where you can execute MySQL queries. On the top menu bar, select Tools > User Manager.

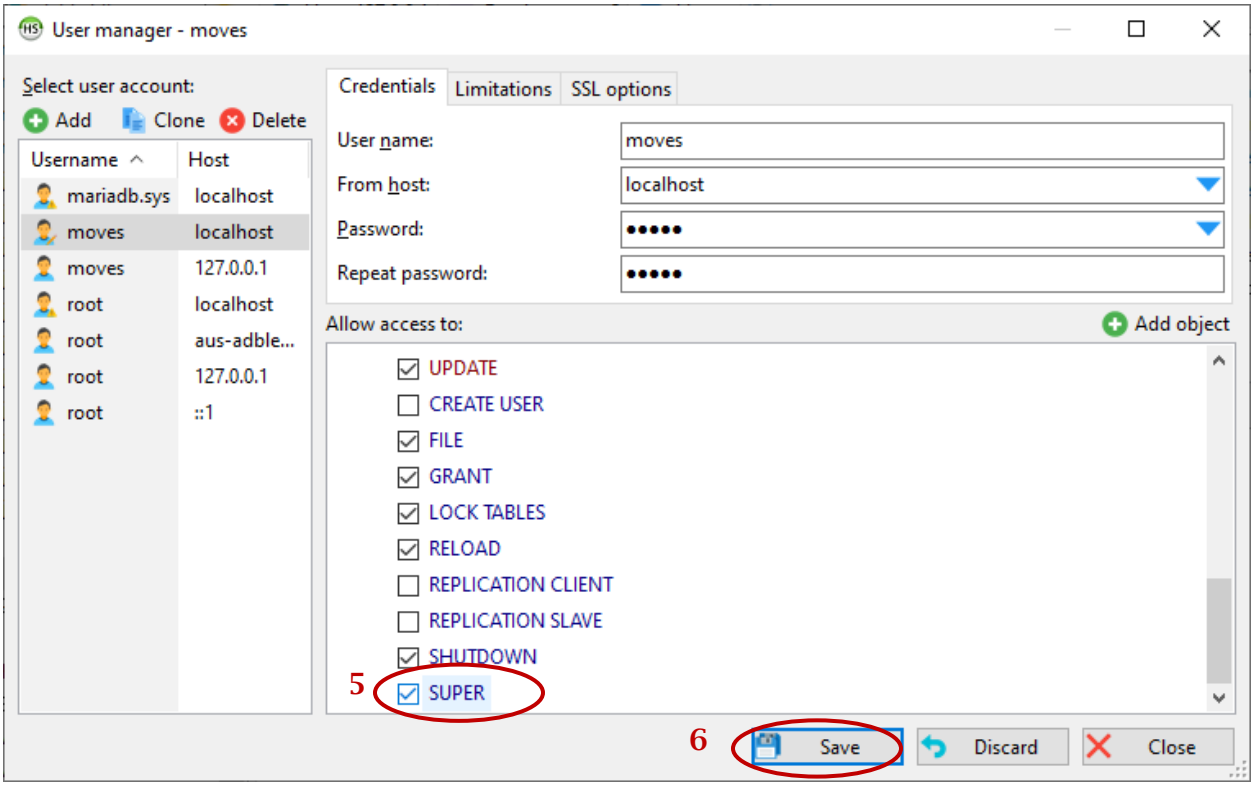


In the User Manager, follow the directions in bullets below; they are also overlaid onto a screenshot of the User Manager.

- (1) Select “moves” user so the manager highlights it in grey.
- (2) Provide the Password and Repeat password.
- (3) Click the dropdown next to Global privileges and
- (4) scroll down to “SUPER”



- (5) Check SUPER
- (6) Click Save.



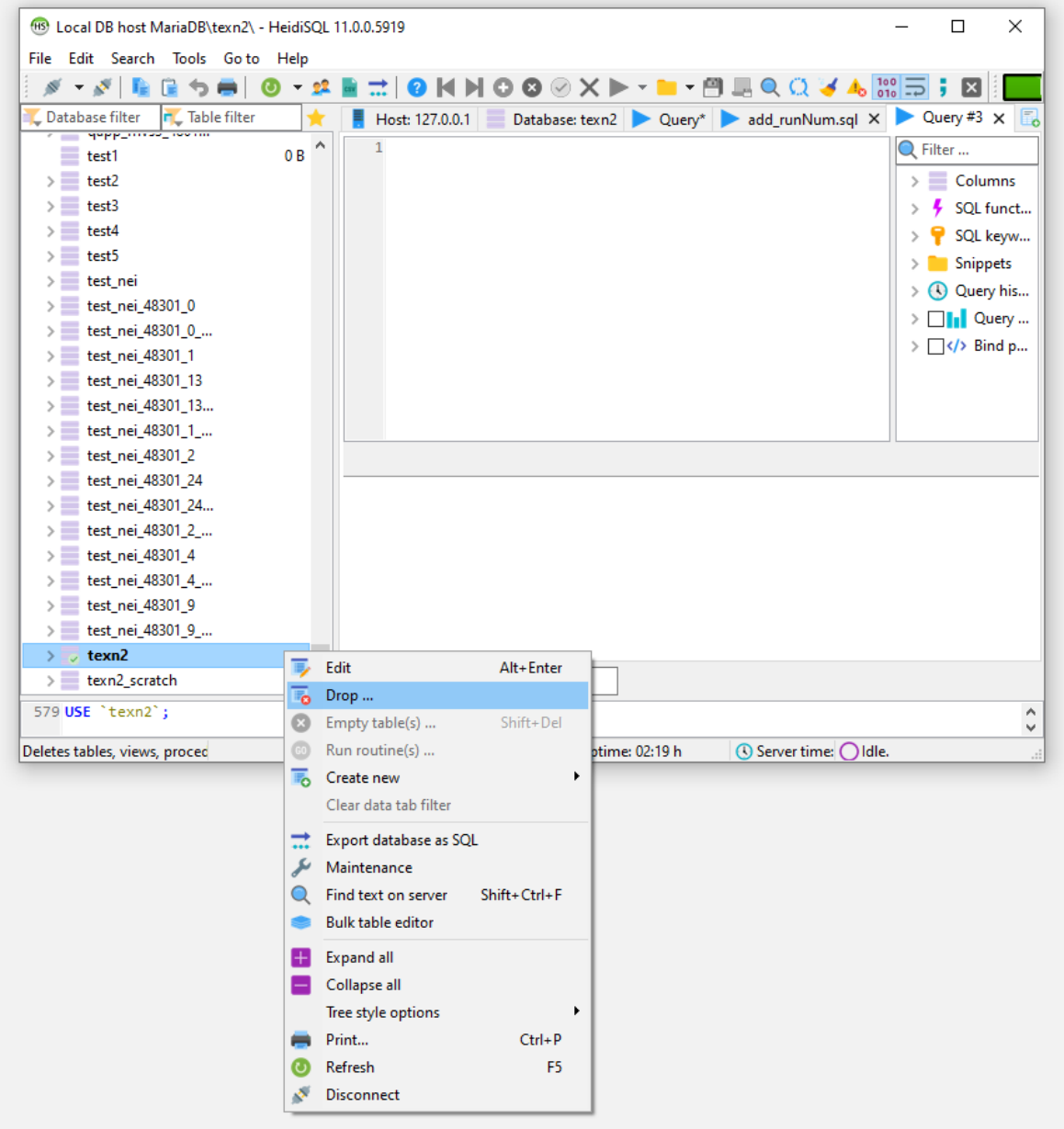
Important: Repeat steps 1-6 for all "moves" users.

Close out of the User Manager when finished updating the moves user privileges.

4. Remove Remnants of the Prior Utility

If you created a TexN2 shortcut associated with the old utility, navigate to it, Right-click and select "Delete."

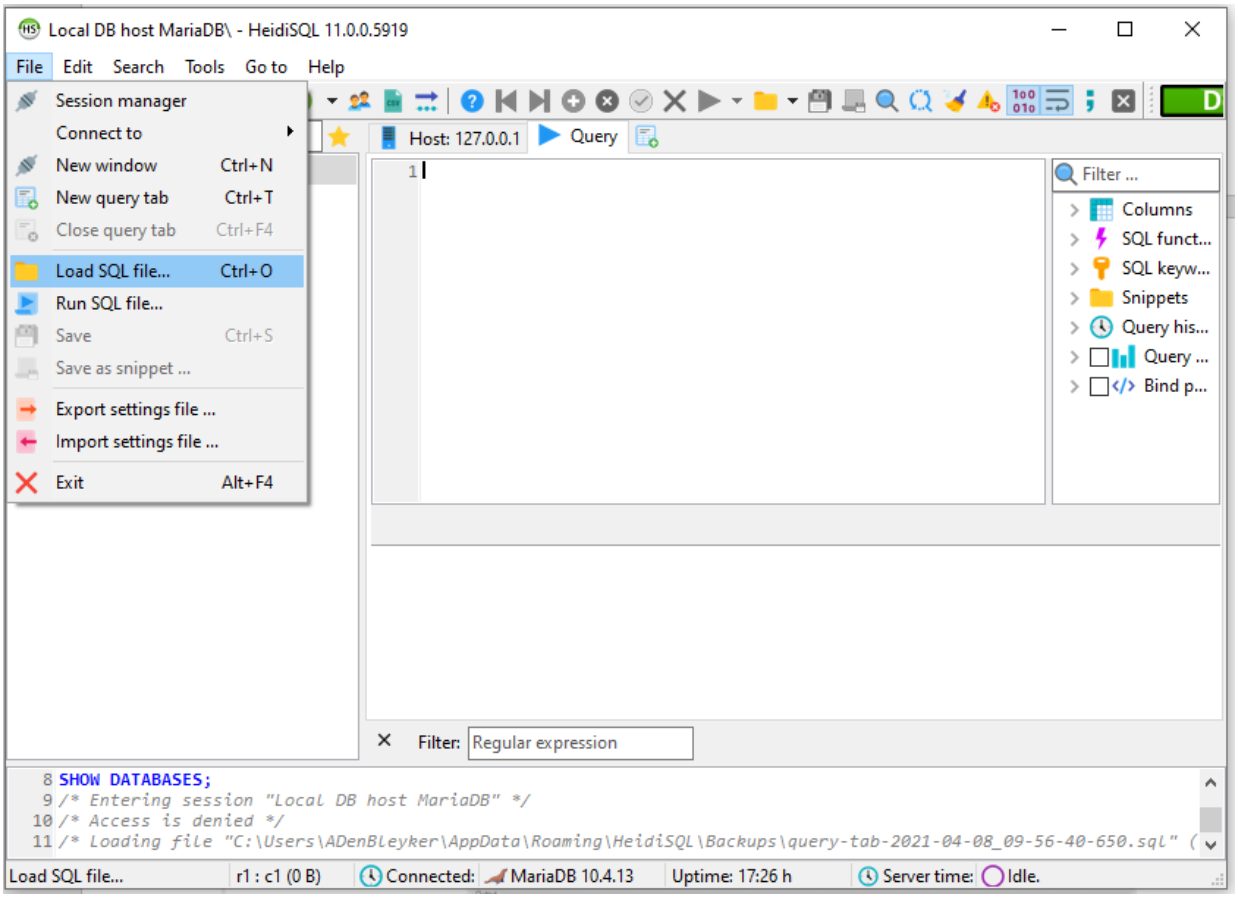
If you have a prior TexN2 database already in your MariaDB data directory, delete it using HeidiSQL as shown below. **Note:** you might not necessarily have a prior TexN2 database. If there is no TexN2 database, proceed to Step 5. Otherwise, Right-click on TexN2 in HeidiSQL and select the option "Drop" as shown below.



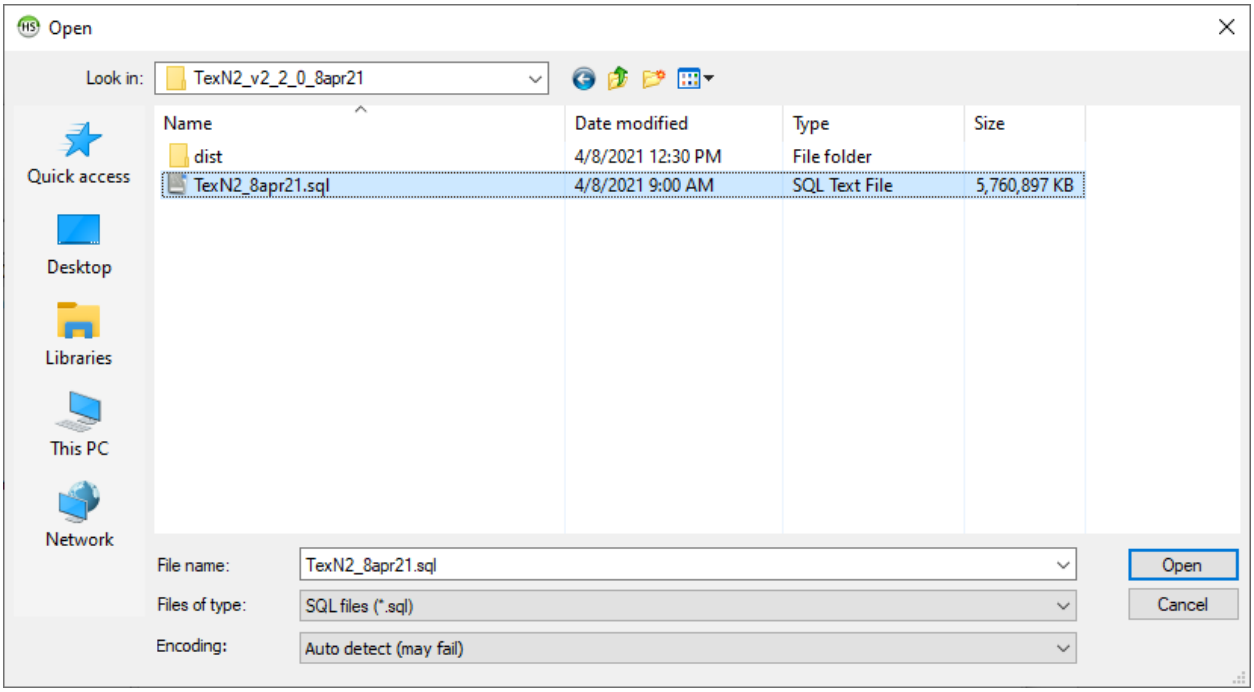
5. Import the New TexN2 Database

The next manual step that must be performed prior to launching the utility for the first time, is to import the new TexN2 database. The database file should have been provided with the utility, and will have a name like TexN2_*.sql, where "*" is a date stamp.

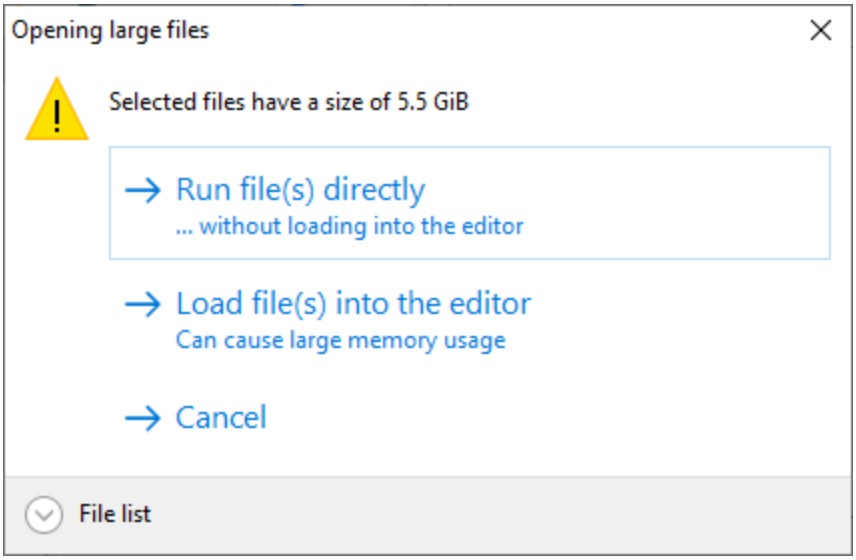
From the File menu at the top of the HeidiSQL screen, choose "Load SQL file":



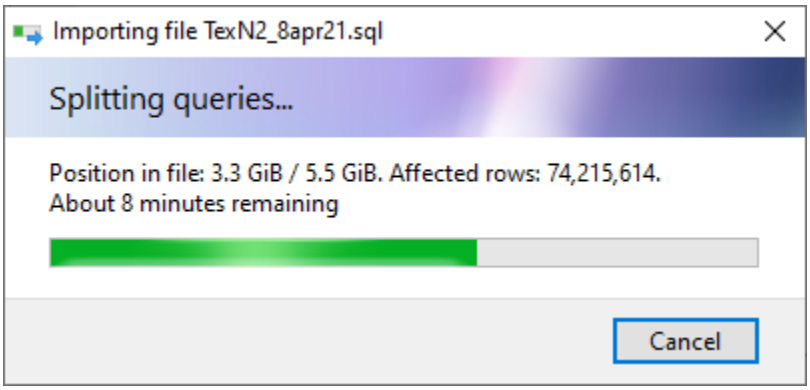
Navigate to the TexN2 database file (TexN2_*.sql) and select it and click Open:



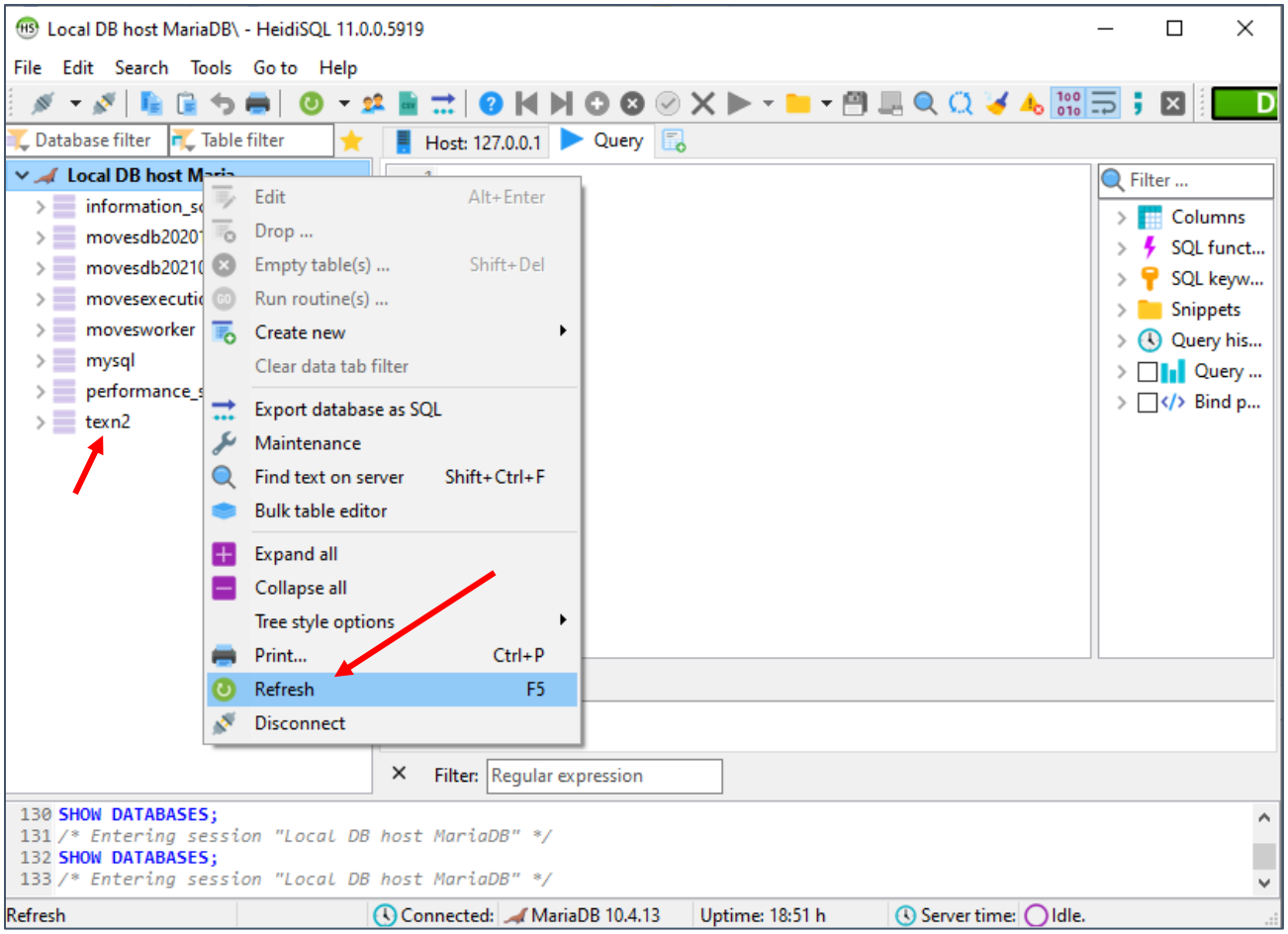
You may see a warning that you are opening a large file. Select the option "Run file(s) directly without loading into the editor."



Now wait for the data import process to complete. This can take a while (around 30 minutes), so be patient.



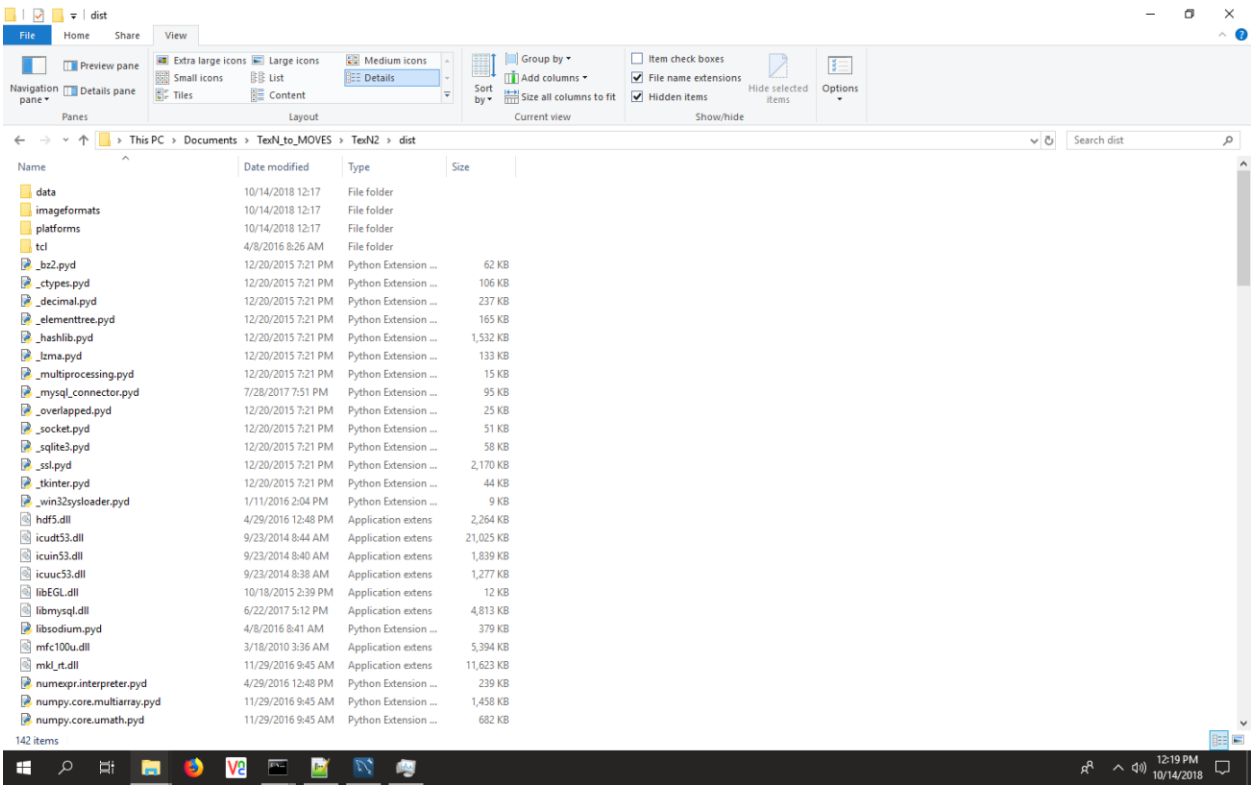
Right-click on your connection name and select refresh to verify that the database has been imported. If it has been imported successfully, you should see "texn2" listed in the left-hand pane:



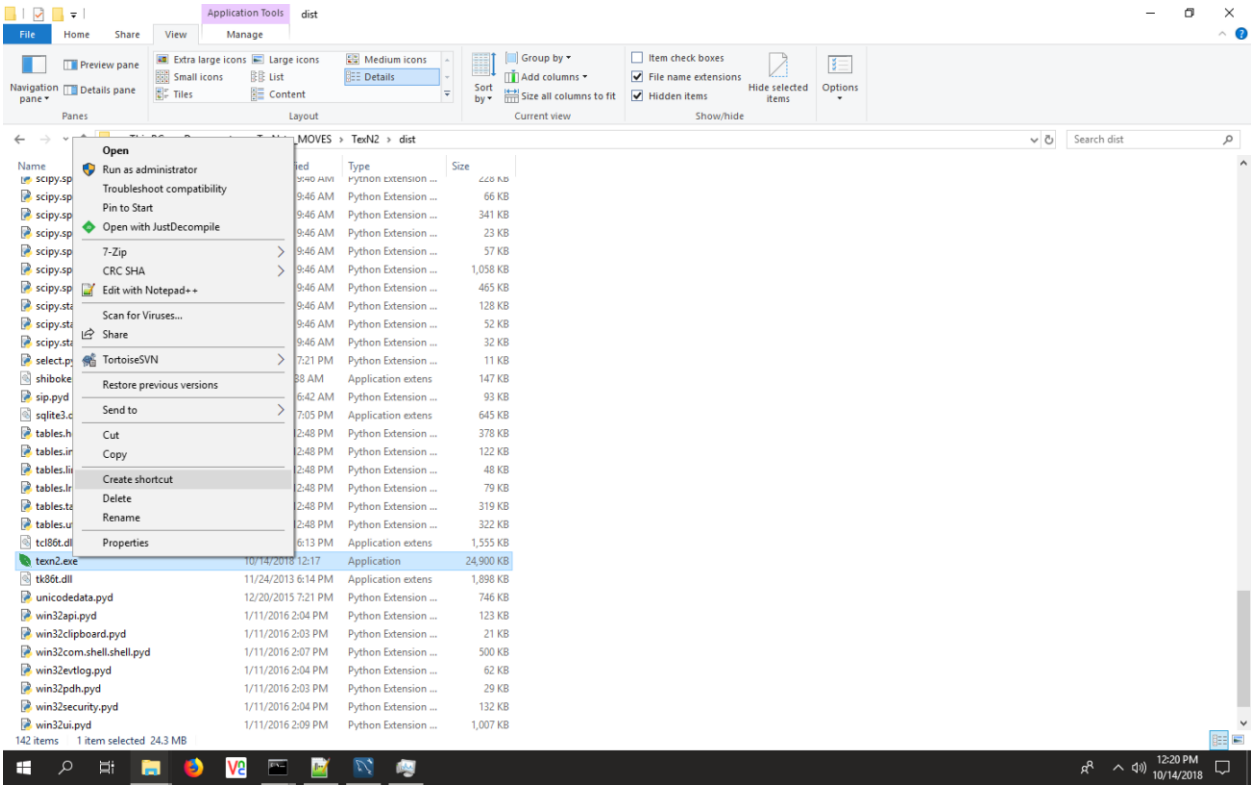
After the database import completes, you are ready to launch TexN2.2 for the first time.

6. Creating a Shortcut to TexN2

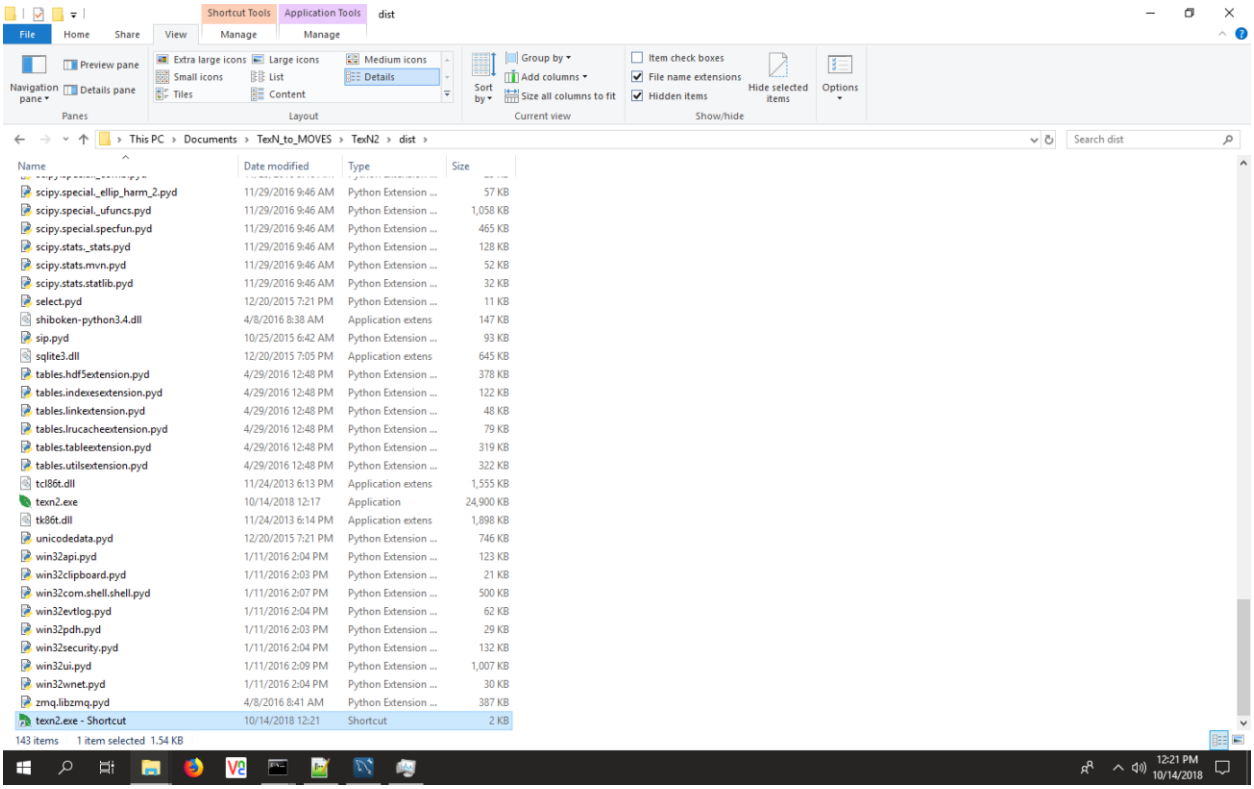
Since TexN2 is designed to work without an installer, it is launched by directly double-clicking the executable file, *texn2.exe*. However, the executable resides in a folder along with a number of other required files, so it is strongly recommended to create a shortcut to the TexN2 executable to avoid the need to open the containing folder to launch the utility; any manipulation of files in this directory runs the risk of deleting or corrupting files that the utility requires to function properly. Creating a shortcut will also make launching the utility more convenient. The contents of the folder containing the executable will resemble the image below:


dist
File
Home
Share
View
Navigation pane
Preview pane
Details pane
Panes
Extra large icons
Large icons
Medium icons
Small icons
List
Details
Tiles
Content
Layout
Sort by
Group by
Add columns
Size all columns to fit
Current view
Item check boxes
File name extensions
Hidden items
Hide selected items
Show/hide
Options
This PC › Documents › TexN_to_MOVES › TexN2 › dist
Search dist
Name
Date modified
Type
Size
data 10/14/2018 12:17 File folder
imageformats 10/14/2018 12:17 File folder
platforms 10/14/2018 12:17 File folder
tcl 4/8/2016 8:26 AM File folder
_bz2.pyd 12/20/2015 7:21 PM Python Extension ... 62 KB
_ctypes.pyd 12/20/2015 7:21 PM Python Extension ... 106 KB
_decimal.pyd 12/20/2015 7:21 PM Python Extension ... 237 KB
_elementtree.pyd 12/20/2015 7:21 PM Python Extension ... 165 KB
_hashlib.pyd 12/20/2015 7:21 PM Python Extension ... 1,532 KB
_lzma.pyd 12/20/2015 7:21 PM Python Extension ... 133 KB
_multiprocessing.pyd 12/20/2015 7:21 PM Python Extension ... 15 KB
_mysql_connector.pyd 7/28/2017 7:51 PM Python Extension ... 95 KB
_overlapped.pyd 12/20/2015 7:21 PM Python Extension ... 25 KB
_socket.pyd 12/20/2015 7:21 PM Python Extension ... 51 KB
_sqlite3.pyd 12/20/2015 7:21 PM Python Extension ... 58 KB
_ssl.pyd 12/20/2015 7:21 PM Python Extension ... 2,170 KB
_tkinter.pyd 12/20/2015 7:21 PM Python Extension ... 44 KB
_win32sysloader.pyd 1/11/2016 2:04 PM Python Extension ... 9 KB
hdf5.dll 4/29/2016 12:48 PM Application extens 2,264 KB
icudt53.dll 9/23/2014 8:44 AM Application extens 21,025 KB
icuin53.dll 9/23/2014 8:40 AM Application extens 1,839 KB
icuuc53.dll 9/23/2014 8:38 AM Application extens 1,277 KB
libEGL.dll 10/18/2015 2:39 PM Application extens 12 KB
libmysql.dll 6/22/2017 5:12 PM Application extens 4,813 KB
libsodium.pyd 4/8/2016 8:41 AM Python Extension ... 379 KB
mfc100u.dll 3/18/2010 3:36 AM Application extens 5,394 KB
mkl_rt.dll 11/29/2016 9:45 AM Application extens 11,623 KB
numexpr.interpreter.pyd 4/29/2016 12:48 PM Python Extension ... 239 KB
numpy.core.multiarray.pyd 11/29/2016 9:45 AM Python Extension ... 1,458 KB
numpy.core.umath.pyd 11/29/2016 9:45 AM Python Extension ... 682 KB
142 items
12:19 PM
10/14/2018

Find the *texn2.exe* file in the folder, right click, and choose "Create Shortcut":

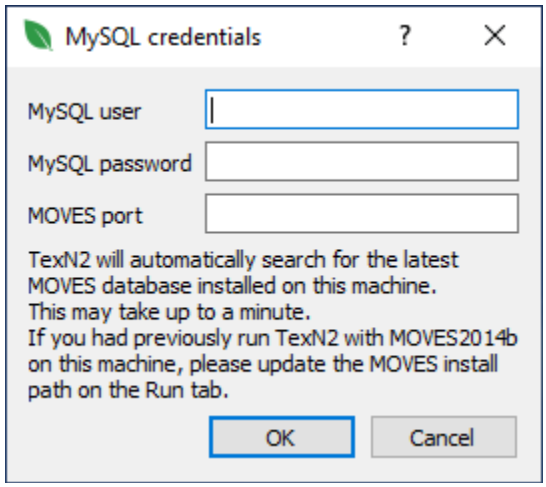


Find the shortcut that was created and drag it to the Desktop or other convenient location:



7. Launch TexN2.2

Navigate to your TexN2 shortcut and double-click to launch. The first time you launch TexN2.2, it will display a dialog box requesting your MySQL username and password and the "MOVES port" which MariaDB uses. Enter lower case "moves" and "moves" for the MySQL user and MySQL password, and enter your MariaDB port number (if uncertain, open a new HeidiSQL instance from the Start Menu and make note of the port number for "MOVES Connection").



There is a note in the MySQL credentials box about two separate issues:

First, TexN2 will look for the latest version of the MOVES default database on your machine. For example, if you have both MOVES databases *movesdb20201105* and *movesdb20210209*, TexN2 will connect automatically to the latter when launching for the first time. The MOVES default database may be changed in the Run tab of the GUI, and the utility will automatically remember (and quickly connect to) the most recent MOVES database used. However, during the first launch the utility may take up to a minute for the utility to find a MOVES database.

The second issue is meant to alert the user to verify the "MOVES install path" in the Run tab after the first launch, because the utility may remember the MOVES2014b install path for the initial launch. Users navigate to the Run tab of the TexN2 GUI and ensure the MOVES install path reflects MOVES3. Subsequent launches of TexN2 will remember the MOVES3 installation path. Note: TexN2.2 will not run with MOVES2014b. Your most likely MOVES3 install path should be C:\Users\Public\EPA\MOVES\MOVES3.0.

After clicking "OK" on the above dialog box, and reviewing the MOVES install path on the Run tab, you are ready to run TexN2.2. This concludes the "Getting started" guide; please refer to the user's guide for any general information on running TexN2.

VI. RECOMMENDATIONS

ERG recommends the TCEQ consider undertaking the following to improve the accuracy of the TexN2.2 utility in the future.

1. Update the TexN2 climate table to match MOVES-Nonroad resolution of all twelve months and 24-hour temperature and relative humidity values. The current climate table uses only four seasonal blocks of months, distributes min/max temperatures to hours, and applies a single relative humidity value to all hours by the four seasons.
2. Streamline reporting of automated RFP results. Currently, the user must export reports ten times for the ten RFP scenarios, and then manually calculate emissions deltas following the steps outlined in the user's guide. An improvement would be to add a new "Automated RFP" report where the user initiates a single export and TexN2 outputs individual scenarios and a summary containing the benefits of each of the successive 10 scenarios.
3. Investigate and consider saving the user selections in the Controls tab (post-processing adjustments, TxLED, and RFG) as part of TexN2 run specification JSON file. Currently these are saved in a system configuration file.

Item 1 is low impact and would primarily affect evaporative VOC emissions from gasoline-fueled equipment. Item 2 would be an efficiency improvement in the user experience during Automated RFP analyses. Item 3 would increase robustness of the utility and remove a burden from the user to verify selections prior to running a previously saved run specification file.

As always, ERG welcomes feedback from TCEQ on TexN2 to incorporate future improvements to the utility.

REFERENCES

US EPA, 2020. "MOVES3: Latest Version of Motor Vehicle Emission Simulator." Available online (as of 2/17/2020) https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

ERG, 2020. "TexN2.1 Utility Diesel Equipment Profile and Growth Factor Updates for Use with MOVES." Prepared for the Texas Commission on Environmental Quality, Air Quality Division, Austin, TX 78711-3087. July 31.

US EPA, 2002. "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling." Available online (accessed 4/1/2021) https://nepis.epa.gov/Exe/ZyPDF.cgi/P100058Z.PDF?Dockey=P100058Z.PDF.

APPENDIX A

Base Year 1990 Population Update to EPA Defaults in DCE Subsectors 0 and 25

Unrelated to the Work Order scope, ERG updated the base year 1990 equipment populations in the TexN2 database for DCE subsectors 0 and 25 as part of the final utility delivery for this project.

The DCE subsector 0 is "Non-DCE" and includes primarily gasoline, liquefied petroleum gas (LPG), and compressed natural gas (CNG) equipment but also some diesel equipment. The description for DCE subsector 25 is "Off-Road Tractors, Misc. Equipment, and all Equipment < 25 hp." ERG applied the EPA default growth factors to generate population for the other calendar years 1999 through 2050 for DCE subsectors 0 and 25. As mentioned earlier in the report, all growth factors were held constant at year 2050 levels for the new future years 2051 through 2060. Table A-1 summarizes the statewide populations for calendar year 2020 before and after the update, highlighting the four DCE subsectors with changes from the update.

Table A-1. Net Changes in Number of Equipment, Texas Statewide, Calendar Year 2020

DCE Subsector ID	DCE Subsector Name	Prior Population	Updated Population	Percent difference
0	Non DCE	9,867,062	11,795,604	20%
1	Agricultural Activities	3,879	3,879	0%
2	Boring and Drilling Equipment	1,035	1,035	0%
3	Brick and Stone Operations	322	322	0%
4	City and County Road Construction	4,912	4,912	0%
5	Commercial Construction	60,397	60,397	0%
6	Concrete Operations	709	709	0%
7	County-Owned Construction Equipment	1,407	1,288	-8%
8	Cranes	7,317	7,317	0%
9	Heavy Highway Construction	3,559	3,559	0%
10	Landfill Operations	599	599	0%
11	Landscaping Activities	17,134	17,134	0%
12	Manufacturing Operations	746	746	0%
13	Municipal-Owned Construction Equipment	7,890	7,310	-7%
14	Transportation/Sales/Services	25,274	25,274	0%
15	Residential Construction	10,480	10,480	0%
16	Rough Terrain Forklifts	22,216	22,216	0%
17	Scrap Recycling Operations	2,126	2,126	0%
18	Skid Steer Loaders	66,317	66,317	0%

DCE Subsector ID	DCE Subsector Name	Prior Population	Updated Population	Percent difference
19	Special Trades Construction	9,028	9,028	0%
20	Trenchers	19,790	19,790	0%
21	TxDOT Construction Equipment	1,773	1,773	0%
22	Utility Construction	17,268	17,268	0%
23	Mining and Quarry Operations	8,147	8,147	0%
25	Off-Road Tractors, Misc. Equipment, and all Equipment < 25 hp	18,597	25,016	35%

The update to synchronize DCE subsector 0 and 25 populations with current EPA default values increased subsector total statewide populations by 20% and 35% respectively, by calendar year 2020. While performing the update, ERG noticed a mistake in DCE subsectors 7 and 13. The mistake was non-zero populations for three diesel SCCs where they should have been zero (0) values, because the SCCs were already included in DCE subsector 25. ERG removed the erroneous populations in those two subsectors, which reduced their statewide population by 8% and 7% respectively. The SCCs were 2270002039 (Diesel Concrete/Industrial Saws), 2270002042 (Diesel Cement and Mortar Mixers), and 2270002081 (Other Construction Equipment). In addition, ERG deleted all populations for calendar years that cannot be used by TexN2.2 or MOVES3: years 1970 through 1989 and 1991 through 1998.

The MOVES3 database stores its nonroad equipment populations at the statewide level for base year 1990 and contains county allocation factors and growth in other tables. ERG ran the model in default mode for Texas to generate the populations in 1990 and 1999-2050. ERG summarized the MOVES output populations by county, SCC, HP, and year and reformatted those values for TexN2 database tables `populationyears` and `populationmain`.

While performing the reformatting, ERG found that one HP bin (75-100 hp) was missing for LPG Forklifts for the counties in the Dallas-Fort Worth and Houston-Galveston-Brazoria areas due to an artifact (from NONROAD2004) resulting in that bin not being included. The other counties did not suffer this artifact because only the Dallas and Houston area counties were part of a prior update to LPG forklifts. ERG added this 75-100 HP category back into `populationyears` and `populationmain` tables and redistributed the prior study data totals from 1990 in TexN to all six HP bins using the EPA distribution among HP bins for the SCC.

Table ES-1. LPG Forklift Equipment Populations, by HP (2005)

HP Min	HP Max	DFW-Survey	DFW-NONROAD	HGBA-Survey	HGBA-NONROAD
25	40	1,140	767	1,230	505
40	50	2,492	1,676	2,689	1,104
50	75	6,963	4,682	7,514	3,084
75	100	0^	0^	0^	0^
100	175	3,048	2,050	3,290	1,350
175	300	15	10	16	7
Total		***13,658***	***9,184***	***14,739***	***6,049***

^HP range not included in NONROAD2004 model.

Finally, in addition to the LPG forklifts there were two other exceptions to the update of DCE 0 and 25 to EPA defaults: ground support equipment (SCCs ending in *8005) and oilfield equipment (SCCs ending in *10010). ERG ensured the populations of those airport and oilfield SCCs remained zero (0) value to continue preventing TexN2 from double counting these categories as TCEQ develops emissions for those sources in separate inventory efforts.