A quick introduction to the *LincSys* software

1. Model description

1.1. An overview

This document presents a quick introduction to the *LincSys* software. It provides a brief description of the core software components (*LincSys.exe* and *LatHydrSim.exe*) and capabilities; user interface layouts, features, and functionalities; how to install and run the software; the data file management and directory structure of the software; and results of model evaluation and simulation examples. For more extensive discussion on these and other related topics the user is referred to the user manual of *LincSys*, which can be downloaded by clicking on the User Manual (PDF) link in the current webpage or can be accessed during runtime through the Help menu of *LincSys'* user interface.

LincSys is a computer program for simulating the hydraulics of linear-move and center-pivot irrigation systems. The name *LincSys* is a mnemonic for the phrase 'linear-move and center-pivot systems'. The *LincSys* software is comprised of a pair of executable files: a hydraulic simulation module, *HydrSimLaterals.exe*, and a graphical user interface (GUI), *LincSys.exe*, through which the user interacts with the hydraulic module.

The GUI of *LincSys* consists of a tabbed form with four windows, namely, the Systems-Projects, Input, Output, and Charts tabpages. Each tabpage provides access to a set of program functionalities, consisting of project management, preprocesing, processing, and postprocessing of project data.

The help utility of the *LincSys* provides resources that the user can tap into through tooltips, a dedicated Help menu that can be activated from the Systems-Projects window, and a set of text files placed in various folders during program installation.

The hydraulic module of *LincSys*, *HydrSimLaterals.exe*, is a numerical model that solves the continuity and energy balance equations (for one-dimensional steady flow through pipes) to determine the lateral-wide distribution of link discharges and nodal heads and an array of additional output parameters for laterals equipped with three different types of emission devices.

The simulation module obtains its input data from a space delimited text file created by the user interface *(LincSys.exe)* and the output data of *HydrSimLaterals.exe* is relayed back to the user interface using text files.

The user interface and the computational module are coupled through an application programming interface that uses the CreateProcess function.

A unique attribute of *LincSys*, compared to earlier center-pivot and linear-move hydraulic models, is that it takes into account the effects of span geometry and key lateral components (namely, *prvs* and drop-tubes) on the system hydraulics and also has sufficient flexibility to accommodate variabilities in lateral hydraulic parameters and field topography.

2. System requirements and installation

2.1. Hardware requirements

Although not thoroughly tested, experience suggests that the CPU, memory, and graphics hardware requirements of *LincSys* are basic and hence it is unlikely that hardware constraints would be series limitations for running *LincSys* in most PC's.

Storage space requirements vary with the number of *LincSys* projects and the size of the individual projects. However, at installation, the *LincSys* folder contains software components (*LincSys.exe*, *HydrSimLaterals.exe*, and .Net Framework 4.8 utilities), *LincSys* sample project data, input data file templates, and help resources related documents, which in total require a storage space of about 120MB.

2.2. Software requirements

LincSys 1.0 is designed for Windows environment and it can be run on machines with Windows 7.0 or later releases of the Windows operating system. The necessary .Net framework utilities are installed along with the core executable files, thus the model has no requirements for additional software accessories.

2.3. Installation, running, and quick exploration of the contents of *LincSys* installation folder

2.3.1. Installation of LincSys

To install *LincSys 1.0* in a PC, the user need to click on the <u>DOWNLOAD</u> link in the current webpage. This will start the installation program *Install_LincSys.exe*. The user can then follow the directions of the installer software to unzip and place *LincSys* files, .Net Framework utility files, and other files in a specified directory.

2.3.2. Running LincSys

Following a successful installation, the user may notice that the *LincSys* icon appears in the user's desktop and the start menu of Windows. In order to run *LincSys* the user simply needs to click on the *LincSys* icon in the start menu or double click on the icon in the desktop. This will open a tabbed form (the user interface of *LincSys*) with the Systems-Projects tabpage enabled (Figure 1).

### 2.3.2.a. The Graphical User Interface (GUI) of LincSys

The GUI of *LincSys* consists of a tabbed form with four windows, namely, the Systems-Projects*,* Input, Output, and Charts tabpages (Figure 1). Each window is designed to provide access to a set of program functionalities. The user interface was developed, by the current authors, with the Basic computer programming language in the Visual Studio Integrated Development Environment (MS, 2019) and is based on the Windows Forms for .Net Framework Ver. 4.8.

The Systems-Projects tabpage represents the main access or entry point to *LincSys*. It is the window that provides access to project management functionalities and help resources. It also enables access to the other tabpages through Windows Forms user interface control buttons. Furthermore, the Systems-Projects window is where the system configuration option for which simulation is to be conducted is specified and the current *LincSys* project is selected. Note that
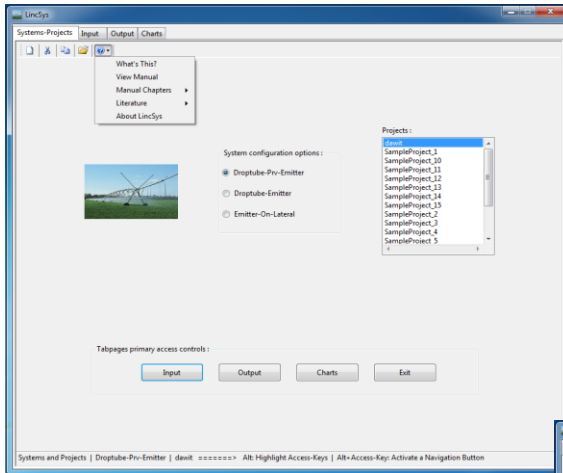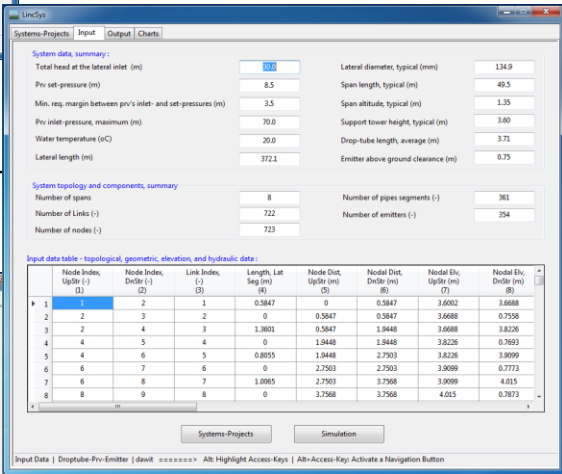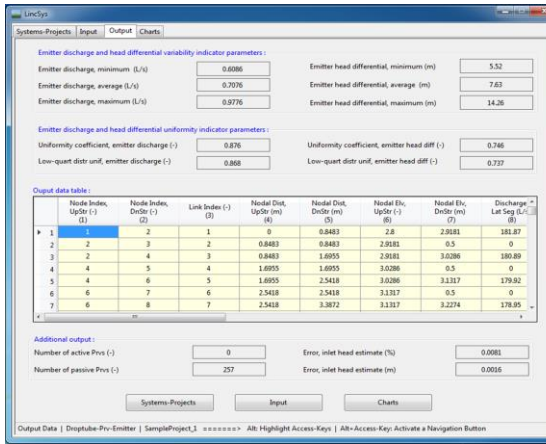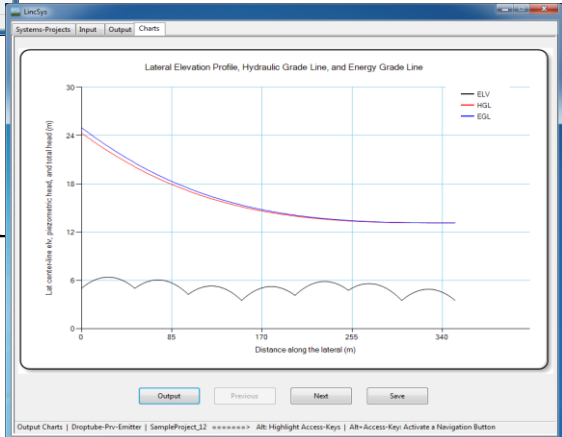
Figure 1. Features, layouts, and control elements of the tabpages (Systems-Projects, Input, Output, and Charts) that form the GUI of *LincSys*

the term project is used in this document to refer to all the input and output data files (of a simulation problem) stored in a folder that bears the name of the project.

The Input tabpage enables access to the input functionality of the model, where input data are displayed and can be edited. If necessary, a simulation run of the current *LincSys* project is also executed from within the Input window. A brief description of the hydraulic simulation module of *LincSys*, including its capabilities is provided here in Section 2.3.2.b.

The Output tabpage is the window where the output data from a successful simulation is displayed. The Charts tabpage provides access to a series of charts (eleven in all) that display a graphical rendering of computed hydraulic parameters.

Standard Windows Forms controls, namely control buttons, textboxes, a listbox, DataGridView tables, labels, chart control, a toolbar, and a dropdown menu are used to issue commands and navigate the user interface. Access to tabpages is mainly enabled through control buttons. An important point here is that direct access to each tabpage through the respective tabcontrols is conditionally possible from the Input, Output, and Charts tabpage (Sections 4.2.3.c, 4.3.1, 4.4.1, and 4.5.1 of the *LincSys* user manual). However, the tabcontrols cannot be used to access the respective tabpages from the Systems-Projects tabpage.

2.3.2.b. The hydraulic simulation module of *LincSys: HydrSimLaterals.exe*

The hydraulic module of *LincSys*, *HydrSimLaterals.exe*, is a numerical model that solves the continuity and energy balance equations (for one-dimensional steady flow through a branched hydraulic network consisting of straight and stationary pipes) to determine the lateral-wide distribution of link discharges and nodal heads (Zerihun and Sanchez, 2021). The model can simulate the hydraulics of linear-move and center-pivot systems with the following lateral outlet discharge metering apparatus configuration options: *(i)* Systems that use drop-tube, pressure regulator, and emitter assemblies to meter outlet discharges along a lateral (labeled as Droptube-Prv-Emittter in the *LincSys* user interface), *(ii)* Systems that use drop-tube and emitter assemblies to meter outlet discharges (named as Droptube-Emittter in the user interface), and *(iii)* Systems in which the emitters are placed directly on the lateral (described as Emitter-On-Lateral in the user interface). Note that the rather more concise phrase of, system configuration options, is often used in this document to refer to the lateral outlet discharge metering configuration options.

The hydraulic simulation module of *LincSys* was developed by the current authors as a standalone simulation model in 2017. It was written in the *C++* computer programming language, as an MS DOS application, within the Visual Studio Integrated Development Environment (MS, 2017). A limited evaluation of the computational module conducted by the authors and cooperators showed that model performance is satisfactory (details can be found in section 6.1 of the user manual).

Data exchange between the user interface and the simulation module takes place through text files. Input data, edited within the user interface, is transferred to the simulation module (*HydrSimLaterals.exe)* and output data of the hydraulic module, following simulation, is relayed back to the user interface (*LincSys.exe*) using space delimited text files.

2.3.3. Quick exploration of the contents of the installation folder

Opening the installation folder with Windows Explorer (or File Explorer) shows that a sizable number of files and a folder have been copied into it. These include the executable files

LincSys.exe and *HydrSimLaterals.exe*, the program icon file *LincSys.icon*, and the program configuration file *LincSys.exe.config.xml*. In addition, a host of .Net Framework utility files with a *.Dll (dynamic link library) extension were copied to the installation folder. Furthermore, the user may notice that a folder named Projects was created under the installation folder.

  LincSys uses a specific directory structure to track and manage projects and store other program related files. The directory structure for project data management is automatically created by the installer under the Projects folder during installation. Directly under the Projects folder there are five subfolders: DrptubePrvEmitter, DrptubeEmitter, EmitterOnLat, HelpDocAndLiterature, and Templates_InputDataFiles. A brief description of the contents of each of these folders will be presented in the next section. However, a more detailed discussion including a description of the contents and formats of each of the files in these folders is presented in Chapter 5 of the user manual.

2.3.3.a. Contents of a system configuration option folder

  The DrptubePrvEmitter, DrptubeEmitter, and EmitterOnLat folders are referred here as system configuration option folders and they contain the *LincSys* project data corresponding to the Droptube-Prv-Emitter, Droptube-Emitter, and Emitter-On-Lateral system configuration options, respectively.

  Opening any of the system configuration option folders, say for instance the DrptubePrvEmitter folder, would show that at installation it contains fifteen sample projects (i.e., folders), named SampleProject_1, SampleProject_2, …, SampleProject_15, each with a complete set of input and output data files.

  Further, opening a *LincSys* project folder, say for instance, the SampleProject_1 folder would show that it contains a total of 9 files with extensions Inp, Out, Dat, Txt and Xlxs, and a subfolder named Charts. The file with the extension Inp is the input data file, while the files with the extensions Dat and Out are the output data files. The file with the extension Txt is a Readme file and is intended to serve as a quick reference resource on the contents of the current project folder. It contains a summary of the dimensions, geometries, and hydraulic characteristics of the lateral components and some qualitative descriptions of the data. The excel file (extension Xlxs), has the same content as the input data file (file with the extension Inp) and is intended to be used as an input data template that can be modified and adapted by the user as needed.

  The Charts subfolder under the SampleProject_1 folder contains 12 files, comprised of 11 image files in Png format and a Readme file. Each image file corresponds to one of the 11 output charts of *LincSys*. A detailed description of the charts files is provided in Section 4.5 of the user manual. The Readme file contains a concise description of the contents of each of the image files in the Charts folder.

At installation, the DrptubeEmitter and EmitterOnLat system configuration folders also contain 15 sample projects with exactly the same name as those of the DrptubePrvEmitter folder. Each of the project subfolders under the DrptubeEmitter and EmitterOnLat folders contains input and output data files with the same names as the DrptubePrvEmitter folder, although the contents differ.

  Note that in *LincSys* the user specifies the project name, which is used as the name of the project folder, but not the names of the input-output data files. The names and extensions of the input and output data files of a *LincSys* project are set by the program internally and do not

change from one project to another. A more detailed discussion on the contents of the input and output data files of the model is provided in Chapter 5 of the user manual.

2.3.3.b. HelpDocAndLiterature folder

Opening the HelpDocAndLiterature folder shows that it contains thirteen documents in Pdf format and a file with a Txt extension. The contents of some of these documents are used by *LincSys* as help information resources that can be accessed through the Help menu from the user interface. The documents in this folder also include a selected set of technical literature that relate to linear-move and center-pivot hydraulics that can be accessed through the Help menu of the GUI. The folder also contains a Readme file, which provides a brief description of the folder's contents. A more detailed discussion on the contents of the HelpDocAndLiterature folder is provided in Section 5.1.2 of the user manual.

2.3.3.c. Templates_InputDataFiles folder

The Templates_InputDataFiles folder contains input data files for laterals with number of spans ranging between 6 and 12. The contents and formats of these files are used by *LincSys* as templates for creating the input data file for a new project. It can be observed that directly under the Templates_InputDataFiles folder there are three subfolders: DrptubePrvEmitter, DrptubeEmitter, and EmitterOnLat. These folders contain the input data template files (text files with extension Inp) for the Droptube-Prv-Emitter, Droptube-Emitter, and Emitter-On-Lateral system configuration options, respectively.

For instance, opening the subfolder DrptubePrvEmitter (under the folder Templates_InputDataFiles) shows that it contains a total of eight text files. Seven of them have the extension Inp and represent the input data template files. It also has a Readme file with the extension Txt, which contains information about the contents and format of the text files in the current folder.

Although the exact contents differ, the number, names, and extensions of files in the DrptubeEmitter and EmitterOnLat system configuration folders are the same as those for the DrptubePrvEmitter folder. Further discussion on the contents of the Templates_InputDataFiles folder is provided in Section 5.1.3.

2.4. Uninstall

LincSys can be uninstalled following standard Windows procedure for uninstalling a program. To uninstall *LincSys*, the user needs to select Control Panel from the start menu in the user's PC Windows desktop. In the control panel window, click on the option Uninstall a program under the heading Programs. This leads to the Control Panel Home window. In the Control Panel Home window move the mouse pointer to the entry Install_LincSys, which is the name of the installer, and then click the left mouse button. This opens up a dropdown menu, then selecting the option Uninstall will initiate the process of uninstalling the program.

2.5. Contents of the User Manual of *LincSys*

The contents of this document is presented in the user manual in six chapters. Chapter 1 provides a quick introduction to the *LincSys* software, including a discussion on the features, layout, and functionalities of the user interface, system requirements and installation, and file management and directory structure. Chapter 2 presents a brief description of linear-move and center-pivot irrigation systems and their significance. A summary of linear-move and center-

pivot lateral hydraulics, as implemented in the computational module of *LincSys*, is presented in Chapter 3. Chapter 4 describes the features and functionalities of the graphical user interface of *LincSys*. A description of the contents and format of the input and output data files and the directory structure used by *LincSys* to manage and track data files is presented in Chapter 5. A discussion on model evaluation results and application examples (sample projects), copied into the *LincSys* input-output data folders during installation, is presented in Chapter 6.

2.6. References

Microsoft Corporation (2017). Microsoft Visual Studio Community 2017.
Microsoft Corporation (2019). Microsoft Visual Studio Community 2019, Version 16.4.
Zerihun, D. and Sanchez, C.A. (2021). *LincSys* Ver 1.0, User's Manual. University of Arizona, Maricopa Agricultural Center, Maricopa, AZ.