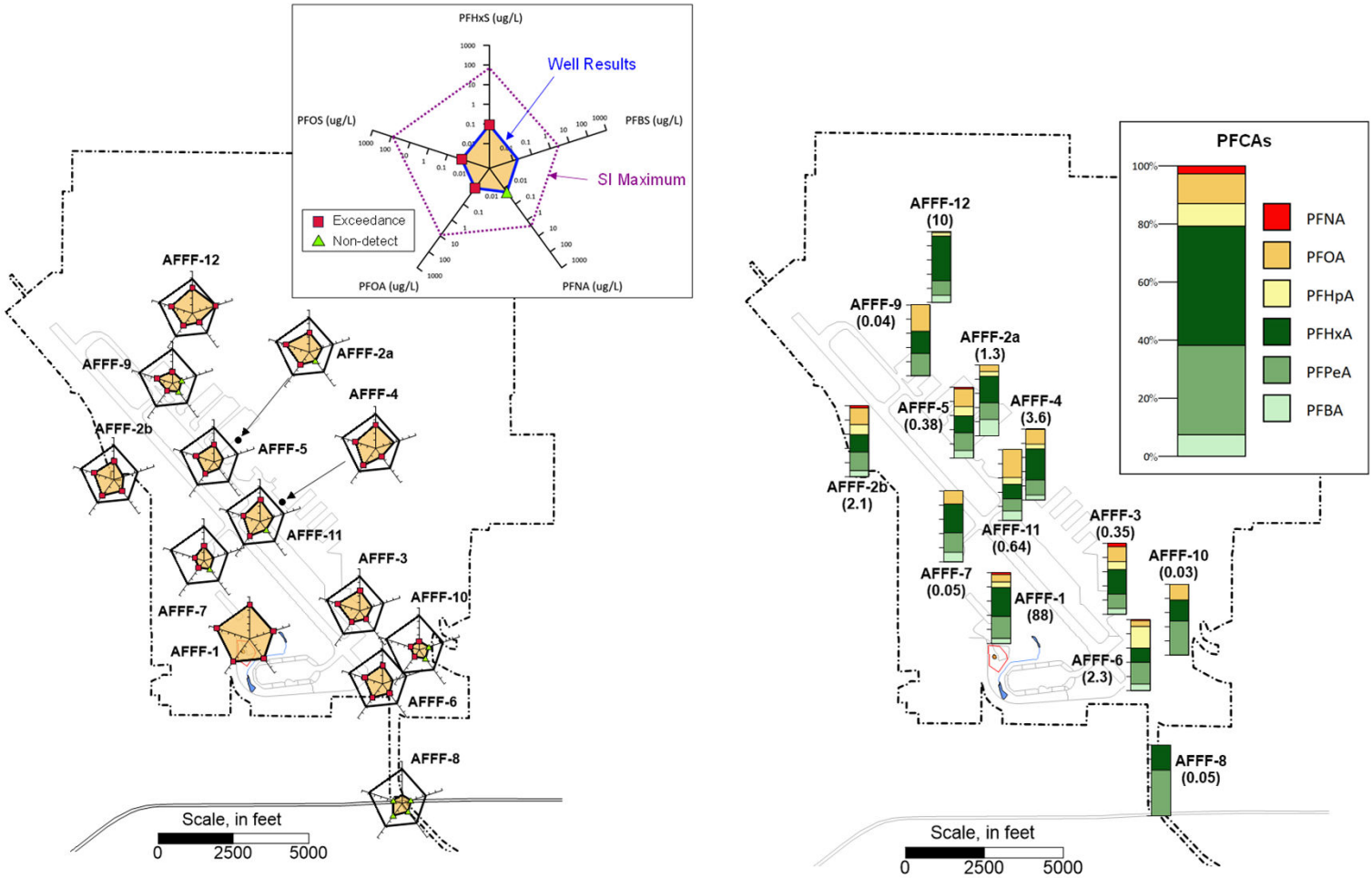
Visual PFAS™ Users Guide:

Introduction

Chapter 1



Reference: Carey et al. (2025) visualization of PFAS trends at AFFF source areas across a South Dakota Air Force Base.

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1.1 Introduction to Visual PFAS™

Visual PFAS™ has been developed with specialized functionality for constructing radial diagram and stacked bar maps, with a focus on supporting PFAS site characterization, remediation performance monitoring, and forensic assessments. The tools in Visual PFAS™ are also applicable to a wide range of other chemicals including chlorinated solvents, petroleum hydrocarbons, metals, geochemical/redox indicators, and radionuclides.

Visual PFAS™ Applications

Visual PFAS™ has been designed with an easy-to-use interface that provides powerful flexibility when it comes to preparing radial diagram and stacked bar maps. The types of visual aids that may be prepared using Visual PFAS™ are ideal for:

- Easily identifying where regulated PFAS exceed criteria on a single site map
- Delineating a PFAS groundwater plume
- Comparing short vs long-chain PFAS at each monitoring well
- Evaluating precursor transformations to regulated and other PFAAs
- Visualizing PFAA attenuation along a groundwater flow path
- Comparing site concentrations to background
- Summarizing TOP assay results overlaid on a site map
- Monitoring PFAS remediation performance
- Source differentiation forensic assessments

Benefits of Using Visual PFAS™

The benefits associated with using Visual PFAS™ for evaluating your site include:

- Prepare effective and powerful visual aids in minutes
- Save time and reduce the cost of analyzing PFAS data
- Impress clients with improved conceptual models and demonstrative visual aids
- Improve communication with non-technical stakeholders
- Develop more persuasive forensic assessments
- Anyone in an office can use this software - no need to tie up specialized graphics support to evaluate PFAS trends, and no need to purchase multiple licenses for use by multiple people at an office location

1.2 Software Overview

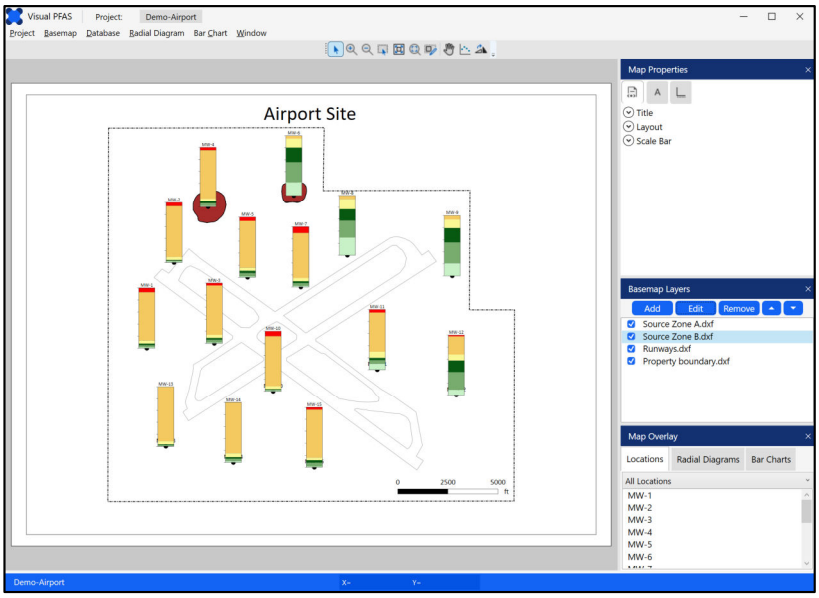
Preparation of the project dataset to be imported into Visual PFASTM is done outside of the software using custom programs already in use by each organization (see Chapter 2). Visual PFAS™ provides a wide range of tools for:

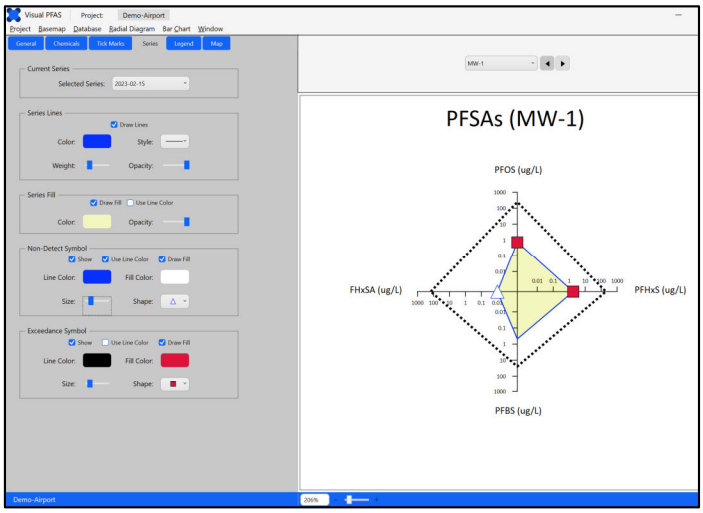
- Preparing a site basemap with imported layers to provide an underlay for radial diagram and stacked bar maps (see Chapter 3);
- Constructing radial diagram maps where the axes represent either measured concentrations or chemical ratios (see Chapter 4); and
- Constructing stacked bar maps to visualize the relative proportion of different chemicals across source areas or along a groundwater flow path (see Chapter 5).

Visual aids constructed using Visual PFAS™ may be printed to a physical printer or a PDF file, exported to various image formats, and/or exported to native files which may be imported into common mapping software including GIS, CAD, or Surfer. For example, Visual PFAS™ maps may be exported to images and then combined and further refined in Microsoft PowerPoint in preparation for a presentation, or imported these images may be directly imported into the body of a report.

Visual PFAS™ has been developed using a similar framework to a previous radial diagram mapping product (SEQUENCE) which was first developed over 25 years ago, with a focus on evaluating natural and enhanced attenuation of chlorinated solvents. A simpler version of this program was also called Visual Bio™.

The main goal of Visual PFAS™ is to increase the range of tools available for analyzing PFAS trends in groundwater, soil, surface water, and sediment samples. With dozens of PFAS constituents now being analyzed with EPA Method 1633, there is a strong need for visualization tools to help assess and then communicate the results of these sampling programs.





1.2.1 Software Licensing

Visual PFAS™ comes with a site license, which means that anyone working permanently at the office location which purchased Visual PFAS™ is free to use the software with the site license. There is no restriction on the number of users who can use Visual PFAS™ at that office location.

It is forbidden for anyone to distribute Visual PFAS™ to users, offices, and/or organizations outside of the purchasing office location. For example, it is forbidden to store or install Visual PFAS™ on a server which may be accessed from outside of that office location. It is also forbidden to transfer or distribute Visual PFAS™ electronically. Copies of Visual PFAS™ may be provided only to employees who work permanently at the purchasing office location via external hard drive or USB.

A Visual PFAS™ license will last in perpetuity; these licenses do not expire, and there are no annual maintenance agreement or subscription fees. Periodic email technical support is available for up to a one-year period with each site license. Future software upgrades will be available for optional purchase, typically on an annual basis.

1.2.2 Installation Requirements

Requirements for using Visual PFAS™ include Microsoft Windows version 10 or 11; and installation of the .NET Framework version 4.8 or higher. The .NET Framework is typically pre-installed with Windows 10 and 11.

1.2.3 Users Guide Organization

The Visual PFAS™ Users Guide contains detailed descriptions of various features and methods for using these tools. A step-by-step tutorial is provided throughout the Users Guide to illustrate all aspects of Visual PFAS™. Map layers and a complete import dataset are provided with the tutorial example project, and may be found in the Visual PFAS™ installatio package provided at the time of purchase (i.e., in the **Demo-Airport Project Files** folder). Remaining chapters in this Users Guide include:

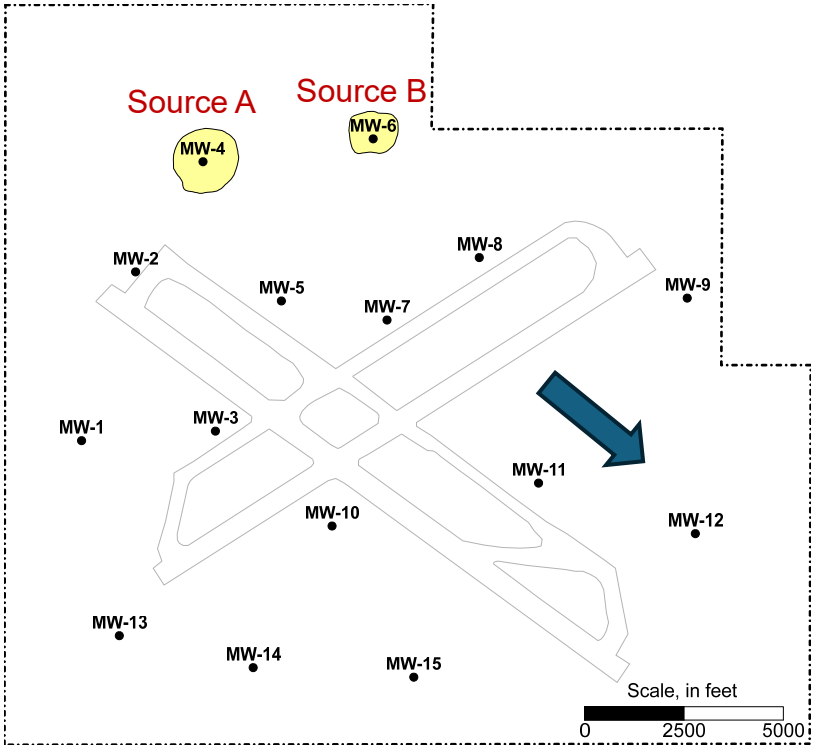
- Chapter 2 – Creating A Project and Importing A Dataset (including detailed format specifications for project datasets to be imported into Visual PFAS™);
- Chapter 3 – Creating A Basemap;
- Chapter 4 – Creating Radial Diagrams; and
- Chapter 5 – Creating Stacked Bar Maps.

1.3 Tutorial Example Project

The tutorial presented in this Users Guide is based on a hypothetical *Demo-Airport* project example. A complete import dataset is provided with the software installation files for set-up to import into Visual PFAS™. (The process used to import this dataset is discussed in Section 2.4.) The *Demo-Airport* site example has the following characteristics:

- Two AFFF-impacted source areas:
    - Source A represents the former fire training area (former FTA) where legacy AFFF products, based on long-chain constituents including a mix of sulfonates (PFSAs) and carboxylates (PFCAs), were used in an unlined pit; and
    - Source B is the location of the current FTA where modern AFFF products are used, resulting in predominantly short-chain PFCAs impacts to groundwater with smaller releases than those that occurred at the former FTA.
- Fifteen monitoring wells (MW-1 through MW-15, inclusive) with eleven wells screened in the shallow zone and four wells screened in the deeper zone of the main aquifer at the site.
- Two recent PFAS groundwater monitoring events where samples were collected at the 15 monitoring wells in February and August, 2023.
- Groundwater flow direction is from the northwest to the southeast.

The site basemap showing the source area and monitoring well locations is presented below, including the direction of groundwater flow downgradient from the source areas.



The February 2023 monitoring event results for this example site are presented below for perfluorinated carboxylates (PFCAs) and perfluorinated sulfonates (PFSAs). The August 2023 monitoring event sample results included in the dataset are similar to the February 2023 event results. (The February 2023 event is used to support the tutorial provided in all Chapters of the Users Guide.)

February 2023 PFCA Monitoring Event Results

Location	Total PFCAs (ug/L)	PFBA (ug/L)	PFPeA (ug/L)	PFHxA (ug/L)	PFHpA (ug/L)	PFOA (ug/L)	PFNA
MW-1	0.4	0.006	0.015	0.01	0.02	0.32	0.029
MW-2	0.6	0.009	0.009	0.006	0.03	0.51	0.036
MW-3	8	0.12	0.36	0.234	0.4	6.56	0.328
MW-4	96	1.44	4.4	2.94	4.8	77.76	4.7
MW-5	45	0.66	2.5	1.7	2.25	35.1	2.808
MW-6	5	1.125	1.7	1.25	0.75	0.25	-0.001
MW-7	38	0.57	1.82	1.22	1.9	28.5	3.99
MW-8	1	0.289	0.28	0.19	0.17	0.06	-0.001
MW-9	0.057	0.012	0.02	0.014	0.008	0.004	-0.001
MW-10	5	0.075	0.066	0.044	0.25	4.15	0.415
MW-11	14	1.4	0.82	0.55	1.4	9.1	0.728
MW-12	12	1.08	3.5	2.34	1.2	3.6	0.252
MW-13	0.09	-0.001	0.002	0.001	0.005	0.084	-0.001
MW-14	0.19	0.004	0.008	0.005	0.012	0.162	-0.001
MW-15	3	0.036	0.19	0.13	0.12	2.4	0.12

February 2023 PFSAs Monitoring Event Results

Location	Total PFSAs (ug/L)	PFBS (ug/L)	PFHxS (ug/L)	PFOS (ug/L)	FHxSA (ug/L)
MW-1	3	0.49	1.8	0.7331	-0.001
MW-2	4.5	0.69	2.7	1.03875	0.1
MW-3	60	9.51	36.25	14.26	0.4
MW-4	725	25	300	250	150
MW-5	509	4	410	85	10
MW-6	0.5	0.10	0.25	0.1506	-0.001
MW-7	287	41.60	176	62.4	7
MW-8	0.3	0.06	0.15	0.0906	-0.001
MW-9	0.2	0.04	0.09	0.0666	-0.001
MW-10	12	2.15	6.6	3.231	0.015
MW-11	50	10.77	23	16.158	0.07
MW-12	10	2.00	5	3.0006	-0.001
MW-13	0.68	0.12	0.39	0.1744125	-0.001
MW-14	0.6	0.12	0.3	0.1806	-0.001
MW-15	3	0.56	1.59	0.8466	-0.001