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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex **(e.g. 3.1)**	Paragraph/ Figure/Table/Note	**Type of comment**	**Commend (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations on each comment submitted**
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

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DRAFT International Standard

ISO/DIS 7673-3

Agricultural Field Operations Data —

Part 3: Irrigation Operations

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7673-3 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19 *Agricultural electronics*.

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Introduction

Part 3 of the Standard pertains to irrigation operations, including all of the activities associated with the application of water with an irrigation system. It focuses on management-level communications and record-keeping. The operations dataset is based around a set of Core Documents: a Recommendation, which describes a suggested course of action; a Work Order, which describes a desired course of action; and a Work Record, which describes what actually happened. This work is based on, and extends, the ISO11783-10 standard for communications between agricultural machinery and Farm Management Information Systems (FMIS) (ISO, 2015).

Software developers and others using this part of the Standard should read, and be familiar with the Core Concepts presented in ISO 7673-1, including the following:

— Business Process Models that are used to describe the flow of data within an integrated irrigation system

— The Actors and their role(s) in the process

— Core Documents and their relationships

— The use of Unique IDs and Compound Identifiers for objects in the Standard which are used by reference in another object

— How the Standard captures the concept of Time in irrigation events

— Specifying Reference, Setup and Configuration data

The sections titled Reference Data, Setup Data, and Irrigation Data describe the classes that compose messages in the Standard:

— UML class diagrams show all the properties

— List with precise description of each class's properties

— Implementation guidelines

Annex A Contains a series of examples which represent common use cases covered by the standard.

Annex C Contains a series of XML examples representing common use cases covered by the standard.

NOTE Readers may note the use of the acronym PAIL in this and other parts of the ISO 7673 standard. PAIL stands for Precision Ag Irrigation Language and was the name used for this set of standards prior to its introduction to ISO. Wherever the PAIL acronym is used, the intent is that PAIL refers to all parts of ISO 7673, collectively.

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Agricultural Field Operations Data —

Part 3:
Irrigation Operations

1 Scope

The purpose of this part of the Standard is to present a data model to represent the specification and reporting of irrigation water and product applications in an irrigation system. The scope includes planning and preparation phases (represented by documents called Plan, Recommendation and Work Order) as well as the recording of as-applied water and products (known as a Work Record). The scope of this document does not, however, include representing the Observations and Measurements that drive tactical decision-making in irrigation (and the creation of Recommendations and Work Orders); that material, corresponding to an irrigation-specific implementation of the ISO 19156 standard, is covered in Part 2 of this standard. This standard should enable a developer to unambiguously represent the data being communicated in various parts of the farmer's business process associated with irrigation field operations in terms of a set of classes based on the ISO 11783 standard, with the understanding that not all farming businesses will necessarily require or support all the documents described above.

The Standard is meant to support the *exchange* of data. The classes and structures described herein are not meant to specify internal structure or the object model of an Farm Management Information System (FMIS) or similar system, nor necessarily a serialization format for the data. While it is easy to draw parallels between an data model and a database schema, the data model defined here is not specifically meant to be construed as a database schema or as the internal structure of an FMIS.

The standard does not specify any type of “summary” report. This is intentional. The information contained in a collection of standard compliant documents will be sufficient to create a summary of irrigation applications. Actual summarization of irrigation requires aggregation, and the method or scope of aggregation is often derived from specific reporting requirements. The Standard is neutral regarding reporting requirements because these requirements are typically derived from a regional, basin, or administrative unit scale and are, therefore, out of scope.

It is important to note that Standard-compliant documents are intended for documenting operations or use of equipment, not the design of equipment. Many characteristics of an irrigation system are relevant for documenting the system’s design but not necessarily for documenting its use. For example, the pipe diameter of a pivot lateral is typically included in its specification. Documenting how much water the pivot applied does not require knowledge of the pipe diameter. Documentation of engineering design is out of scope for the Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For updated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7673-1, *Agricultural Field Operations Data — Part 1: Core Concepts*

ISO/FDIS 6709, *Standard representation of geographic point location by coordinates*

ISO 8601, *Data objects and interchange formats — Information interchange — Representation of dates and times*

ISO/IEC 9834-8, *Information technology — Procedures for the operation of object identifier registration authorities — Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*

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ISO 11783-10, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 10: Task controller and management information system data interchange*

ISO/IEC 13249-3:2011, *Information technology — Database languages — SQL multimedia and application packages — Part 3: Spatial (WKT)*

ISO 19109, *Geographic information — Rules for application schema*

ISO 19112:2003, *Geographic information — Spatial referencing by geographic identifiers*

ISO 19156:2011, *Geographic information — Observations and measurements*

ISO/IEC 19510:2013, *Information technology — Object Management Group Business Process Model and Notation*

ISO/IEC 19757-3:2006, *Information technology — Document Schema Definition Language (DSDL) — Part 3: Rule-based validation — Schematron*

ISO 22006:2009, *Quality management systems — Guidelines for the application of ISO 9001:2008 to crop production*

No WMO, 8. Guide to Meteorological Instruments and Methods of Observation, 7th Edition. 2008. Geneva

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
alternate furrow irrigation
A surface irrigation practice where furrows are used as channels to distribute water across a field and half (or approximately half) of the furrows are wetted separately, in an alternating fashion.

3.2
block
A subdivision of an irrigation system that enables application of water to a portion of the total area irrigated by the system and can be controlled independently of other blocks.

3.3
chemigation
an injection of agrochemicals, such as pesticides, herbicides or other growth-enhancement products, to the irrigation system, together with irrigated water.

[SOURCE: ISO/IWA 20:2017]

Note 1 to entry: Plant growth regulators are included in the category of products that can be applied through chemigation.

3.4
corner arm
An articulated span of a pivot, typically the last span, designed to rotate relative to the adjacent span and enables irrigation of a portion of the corners of a rectangular area.

3.5
Data exchange
a transfer of information between two or more entities where the information is typically in the form of electronic documents.

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3.6
data logger
See telemetry system (telemetry system)

3.7
data provider
a person or entity responsible for collecting, storing, and providing information used in **data exchange**.

3.8
endgun
set of one or more sprayers or sprinklers installed on the distal end(s) of a centre-pivot or moving lateral irrigation machine to increase the irrigated area, and usually operating for only a portion of the time to conform to field boundaries.

[SOURCE: ISO 11545:2009(en), 2.6]

3.9
evapotranspiration
the total evaporation of an area covered with vegetation. It is comprised of water that is intercepted by the vegetation followed by evaporation, the evaporation from the dry surface of plant leaves (transpiration), and the evaporation from the soil.

[SOURCE: ISO 6107-8:1993]

3.10
fertigation
the application of fertilizers with irrigation water (see chemigation).

3.11
field operation
a task or activity, whether planned or actual (i.e., that already happened), that is connected with the production of a crop. Planting, spraying, spreading, tillage, irrigation and harvest are all examples of field operations.

[SOURCE: ISO 7673-1]

3.12
grower
a person or entity responsible for managing agricultural production.

3.13
irrigation collection
one or more irrigation items which together document water application on a particular field.

3.14
irrigation item
information needed to document when, where, and how much water was or should be applied on a particular field.

3.15
irrigation efficiency
the amount of productivity (yield) in relation to the amount of water applied. Irrigation efficiency units are normally presented as the weight of yield per volume of water applied.

[SOURCE: ISO/IWA 20:2017]

3.16
irrigation setup
the arrangement and configuration of irrigation equipment at a particular time.

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3.17
irrigation system
the physical components and configuration of pipes, components, and devices installed in the field for the purpose of irrigating a specific area used to apply water by irrigation.

[SOURCE: ISO 16075-2:2015]

3.18
irrigator
a person or entity responsible for managing the application of water for agricultural production.

3.19
message
a package of information (typically a document in electronic format) exchanged at a particular time for a particular purpose wherein the information pertains to the execution of a particular agricultural operation.

3.20
micro-sprinkler
sprinkler that distributes water in a dynamic or static way, either in circular area or part circular area, with a flow rate not exceeding 200 l/h

[SOURCE: ISO 24120-3]

3.21
pivot span
A contiguous portion of a pivot irrigation system.

3.22
recommendation
a document containing one or more irrigation collections which specify when, where, and how much water should be applied.

Note 1 to entry: Recommendations are assumed to be created by a person with expertise, that is *recommending* a course of action. Their meaning is distinct from that of work orders (work order), which are created by a person with authority, and represent the decision to irrigate as specified.

3.23
section
a contiguous portion of an irrigation system, irrigated using the same method (e.g. sprinklers, tape, furrow, etc.), and with the same nominal application rate.

3.24
section flow
an amount of water emitted from a section at a particular time and at a particular location.

3.25
set
A collection of one or more blocks (block) within the same irrigation system that are irrigated simultaneously and receive approximately the same depth of application. The blocks associated with a set may change during an irrigation season.

3.26
surface irrigation
In the context of this standard, irrigation occurring where the majority of the system is unpressurized, and water is distributed across a field via ditches, siphon tubes, or other devices operating without artificial pressurization.

3.27
section setup
The setup and configuration data necessary to specify essential features of a spatially distinct portion of an irrigation system.

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3.28
system controller
the device that controls the irrigation system's basic functions, including speed, direction of travel, water output, the operation of *endguns* (3.8), as well as additional pumps. It may include the combination of the system's control panel and an associated *telemetry system* (3.29).

3.29
telemetry system
Electronic systems for transmission of field-collected data, and receipt of command data.

3.30
variable rate irrigation
a method of managing the amount of water applied per unit area in a spatially explicit manner. In the context of pivot and linear systems, VRI regulates the system speed and provides the ability to turn sprinkler valves on and off. There is no conventional definition for VRI in other types of irrigation systems (e.g., drip, wheel lines, travellers).

3.31
variable speed irrigation
VSI
a method of managing water application by varying the speed of the centre pivot as it moves around the field.

3.32
Work Order
a set of instructions, given by someone with authority specifying a course of action. An irrigation work order describes the amount of water to apply to a given piece of land over a specific time period.

Note 1 to entry: Work orders are assumed to be created by a person with authority, that is communicating the decision to irrigate. This is distinct from recommendations (recommendation), which are assumed to be created by a person with expertise, that is recommending a course of action.

3.33
work record
a document that describes what actually happened while performing the field operation. It may differ from the work order because the operator performing the field operation may have had to make adjustments to particular conditions (e.g., suspended the operation because the ground was too wet and returned the next day).

4 Symbols (and abbreviated terms)

4.1 Note on multiplicity of properties

This standard defines an abstract object model. The standard utilizes UML diagrams to *specify* the classes and their properties. The body text of the document *describes* the properties. For the reader's convenience, we have included the multiplicity specification in the body text of each classes' description. The following table shows the UML multiplicity specification and its meaning, as used in the body text of this standard. When the multiplicity is not shown (in the diagram or the description), the multiplicity shall be assumed as[1].

Table 1 — Multiplicity codes

Text	Meaning
[0..1]	The property is optional and may appear only once
[1]	The property is required and shall appear only once
[0..*]	The property is optional and may appear any number of times
[1..*]	The property is required and may appear any number of times

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5 The Management Process

The Standard is built around an assumption that irrigation is managed and that the management can be defined by a process. This assumption is derived from the business process that is typical of irrigation management service providers and irrigation managers at more extensive operations. All the classes and objects defined in the standard are based on business practices. Agronomic processes are not ignored but instead are embedded in the business processes. The BPMN diagram defines all of the actors, processes, and messages (message) that are relevant to the irrigation management process.

NOTE The specific processes formally documented by a given farming business will vary based on size, jurisdiction, regulatory compliance requirements, underlying limiting factors to production, and so forth. The BPMN model shown should thus not be interpreted as implying that farming businesses should support all of the documents in order to conform to this Standard. Additionally, not all farming businesses will have separate actors in the roles shown. In some cases, for example, the grower, the irrigator (3.18), and the advisor who provided the recommendation (3.22) may all be the same person.

5.1 The In-Season Management Process

Figure 1 shows a Business Process Modelling Notation diagram of the irrigation management process. This diagram is also shown in Part 1 of this standard which contains a discussion on the content and meaning of this diagram. Part 1 also includes a primer on BPMN diagramming. A more detailed discussion is presented here.

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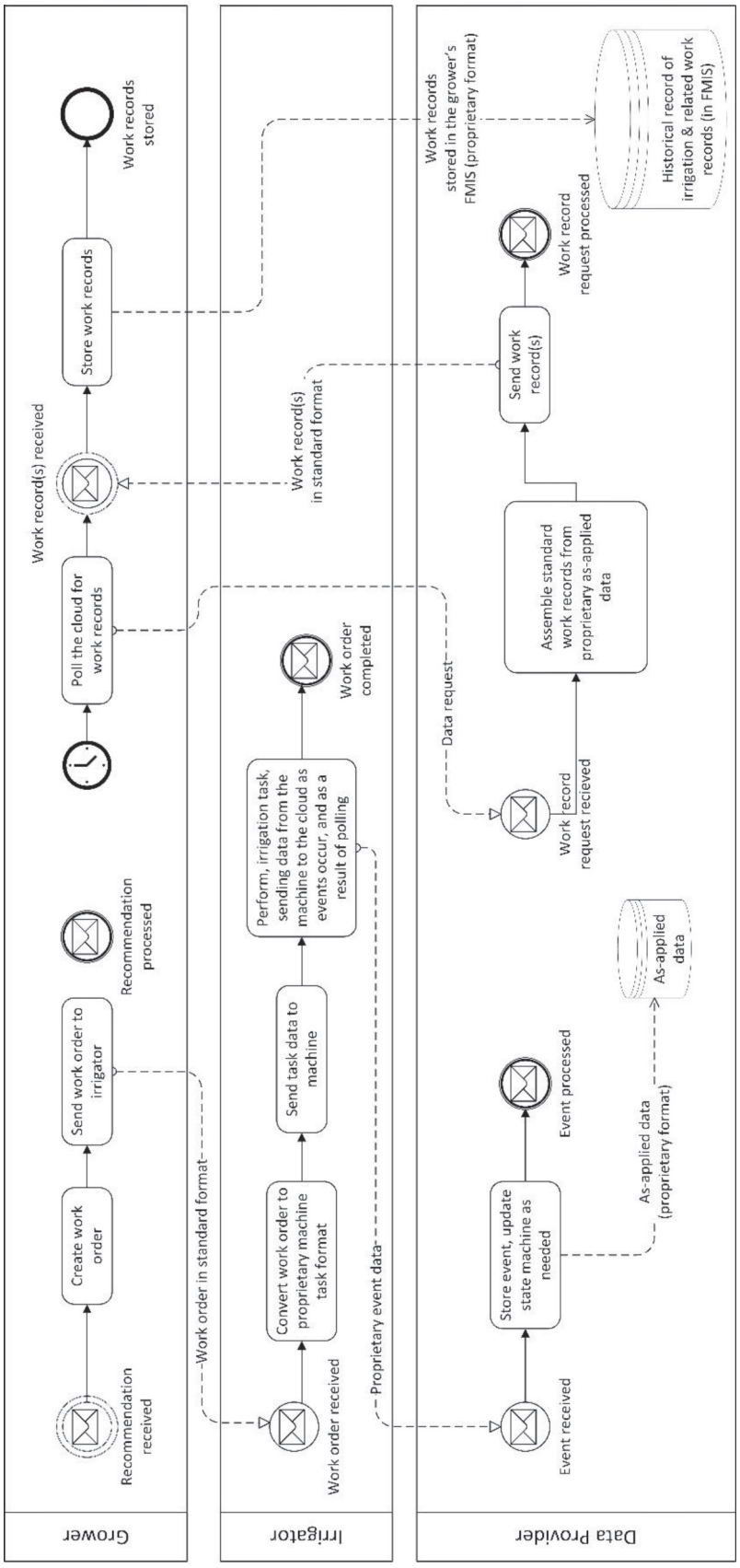


Figure 1 — The BPMN diagram for in-season management operations

In the figure, the dashed lines represent messages that actors exchange during the process of implementing irrigation during the growing season. Not all the messages are in the Standard format. Non-standard

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messages are excluded from the standard because they include proprietary information. Non-standard messages are indicated as such in the diagram. The standard does not stipulate how to implement the processes; it only presumes that these processes occur and that the messages are passed. Some aspects of the processes may be indirectly limited by constraints of the context of the messages. While it is technically possible for the message exchange to happen manually (i.e., by paper or verbal exchanges), the standard assumes that the message exchange is facilitated by an FMIS or another software system. Finally, the diagram does not precisely specify the standard, only the context in which the actors exchange messages.

5.1.1 Grower Process: Work Record request/received

— The BPMN begins with the receipt of a recommendation. The standard assumes that someone with expertise created the recommendation and did so using field measurements that indicate a need for irrigation. Part 2 describes the process by which recommendations are created.

— The Grower creates a Work Order (3.32) based on the Recommendation. The Work Order may differ from the Recommendation based on the Grower's knowledge or preferences.

— The Grower then transmits that Work Order to the Irrigator, the person in charge of performing the operation.

For small or mid-sized farms, the Grower and Irrigator is often the same person. In that scenario, the message exchange is primarily symbolic. The Work Order represents the decision by the Grower.

5.1.2 Irrigator Process: Work Order Received

— The process begins when an Irrigator receives a Work Order.

— The Irrigator then uses the work order to set up the irrigation task. The exact nature of this step will depend on the hardware involved: it may range from sending the standard-format Work Order in electronic form to a telematics system to using the information on a printout of the work order to guide the manual programming of an irrigation system panel. The specifics of what happens at this step are not in the scope of this standard.

— The Irrigator starts the machine and performs the task.

5.1.3 Data Provider Process: Receive Event Data

— While the machine operates, it will generate a series of events (e.g., the machine is on and applying water, the machine turns off, there is low pressure or other error conditions, etc.)

— The event data is assumed to be logged by a Data Provider (3.7), who will translate the proprietary sequence of events into standard-format Work Records (3.33).

— The process begins when an event is received by the Data Provider.

— The Data Provider stores the event data on its own proprietary state machine database. The specifics of the data involved are outside the scope of this standard.

— The process ends after the storage operation is complete.

5.1.4 Grower Process: Work Records Needed

— The process begins when the Grower decides that he/she needs Work Records

— The Grower sends a request to the Data Provider

— The Data Provider assembles the Work Records collected during execution of the Work Order and sends them to the Grower. The messages may also include Work Orders with status updates for work that is still ongoing.

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— After receipt of the Work Records, the Grower may choose to store these records in a proprietary database. The Data Provider who stores these records is not necessarily the same provider that generated the records.

6 Central Concepts

This section describes fundamental concepts that are used throughout the standard. The concepts presented in this section manifest in the standard as class definitions. The following sections contain the details of each class, its attributes, relationships, and constraints. This section introduces each class as a concept and describes its purpose.

The scope of this Standard includes eight separate irrigation technologies (centre pivot, linear, traveller, drip, surface, solid set, hand lines, wheel lines). The particular implementation of the classes for each technology will be somewhat different, since some irrigation systems (e.g., centre pivot, linear, traveller) have automated movement and thus the irrigated area changes over time, whereas others do not, etc. Table 2 below shows the key system characteristics that were used to categorize the systems.

— **Technology**: the name of the system type

— **Sections**: does the system use static (constant over time) or dynamic (changing over time) definitions of section setups (3.27).

  — **Static:** the spatial footprint of Sections is constant over time (i.e., defined at the section setup level (3.27)

  — **Dynamic:** the spatial footprint of Section definitions change over time (e.g., succession of polygons, defined in the IrrItem.SectionFlow instances)

  — **Both:** the spatial footprint may be static or dynamic

— **Uses Sets**: are Sections grouped into a collection of areas which are irrigated simultaneously

— **Setup volatility**: does the setup data vary often during an irrigation season

— **Endgun setup**: does the system need setup information for an endgun (3.8)

Table 2 — Irrigation system features relevant for categorization of Irrigation System type

Technology	Sections	Uses Sets	Setup volatility	Endgun setup
Centre pivot	Both*	No	Low	Yes
Linear	Both **	No	Low	Yes
Traveler/Big Gun	Both **	Yes	High	Yes
Drip	Static	Yes	Medium	No
Surface	Static	Yes	Medium	No
Paddy	Static	Yes	Low	No
Solid set	Static	Yes	Low	No
Hand lines	Dynamic	Yes	Medium	No
Wheel lines	Dynamic	Yes	Medium	No

* Sections along the primary system are described in radial form. Sections on a *bender* are described in radial form around a local centre of rotation. Sections corresponding to a swing-arm corner are described as dynamic polygons.

** Linear and Traveler/Big Gun systems cannot be described in the radial shorthand used for pivots. Therefore, their coverage is a dynamic polygon. Note there are two different ways of setting this up: multiple static sections (that have a fixed footprint and only get water allocated to them when the system passes over them) and dynamic sections (that have a dynamic polygon coverage that can represent the water applied between two different moments in time).

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6.1 Describing Irrigation Systems and their Component Parts

In the context of ISO 7673, irrigation systems are comprised of a collection of one or more components for delivering water to a given area. These components can be stationary, moving in a plane, or rotating around a point. The ISO 7673-3 data model contains abstract specifications of these components as they relate to documenting when and how much water is, was, or should be applied to a particular area. The fundamental abstraction is the SectionFlow class described in Section Flow and the IrrItem described in IrrItem. Each type of irrigation system has different physical constrains that will determine how to define the SectionFlow and IrrItem objects in irrigation documents. The following sections define the specific concepts used to relate the particular system components to the abstract concepts defined in 7673-3.

ISO 7673-3 defines two concepts that will help facilitate documenting water use with irrigation systems:

> **Block**: A subdivision of an irrigation system that a) covers a portion of the total area irrigated, and b) can be controlled independently of other blocks. (block)
>
> **Set**: A collection of one or more blocks within the same irrigation system that are irrigated together. The blocks associated with a set may change during an irrigation season. (set)

A Set is an emergent property of the system's management. A Block is a property of the system's design. The application rate, within a given Block, is determined by the design of the irrigation system. The depth of application is determined by the management of the Set. The definition of these two terms depends on the system type.

Spatial extent can be specified with varying degrees of abstraction, ranging from explicit time-specific data, to abstract specification via relationships with other classes. Details how to specify the spatial extent in setup and configuration data, is defined in SystemSectionSetup. Implementors may equate Blocks with CropZones (ISO 7673-1, Clause 9.2.10), because this simplifies documenting crop management (e.g., when the Blocks contain different crops), but this is not required.

6.1.1 Drip Irrigation Systems and their Component Parts

Within the context of Drip Irrigation systems, Block and Set have the following interpretation:

> **Block**: A subdivision of a drip irrigation system that enables irrigation of a portion of the total area irrigated by the system and can be controlled independently of other blocks.
>
> **Set**: A collection of one or more blocks within the same irrigation system that are irrigated together. The Blocks associated with a Set may change during an irrigation season.

Figure 2 illustrates Blocks in an example irrigation system. This example system has a rectangular area subdivided into six parts, where each part has its own valve controlling flow to that part. Each one of these parts, controlled by a single valve, is a Block in the context of 7673. Each Block shall have one SectionSetup instance in the IrrSetup instance. Each of these SectionSetup instances corresponds 1-to-1 to the Sets in the physical irrigation system. Figure 3 shows a schematic view of a WorkRecord corresponding to a single irrigation event where the entire field (all the Blocks) are irrigated simultaneously.

The following constraints apply to drip irrigation systems:

— Each Block shall have exactly one SectionSetup

— SectionSetup shall use the SpatialFootprint property (not the InnerDistance or OuterDistance properties)

— SectionFlow instances corresponding to a single Set shall be grouped in a single IrrItem instance.

A typical scenario with drip systems in water-scarce areas involves having a declining flow rate during the irrigation season. Guidelines for Drip Irrigation contains a detailed example of how to produce irrigation records that accommodate this scenario. The examples also demonstrate best practice for documenting Sets in ISO 7673-3 irrigation documents.

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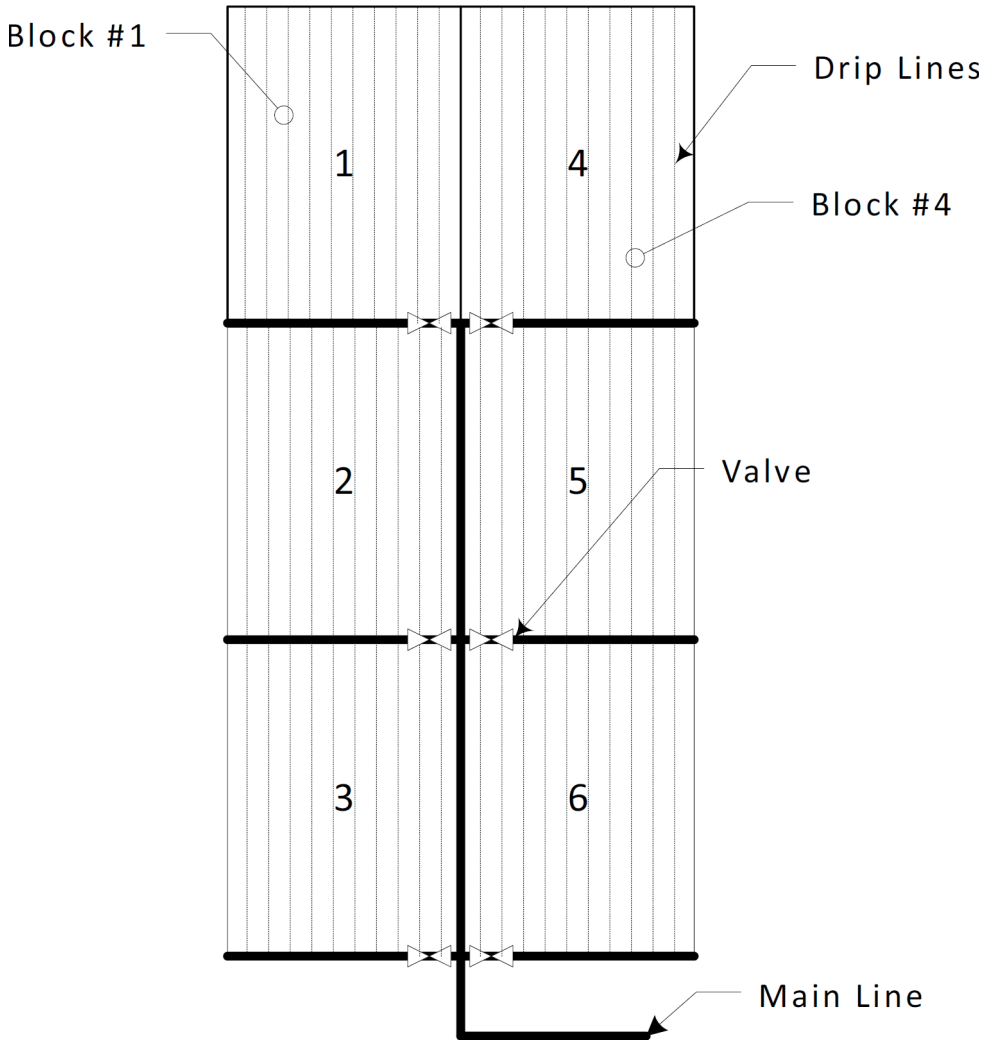


Figure 2 — Schematic diagram of a Drip irrigation system having six Blocks

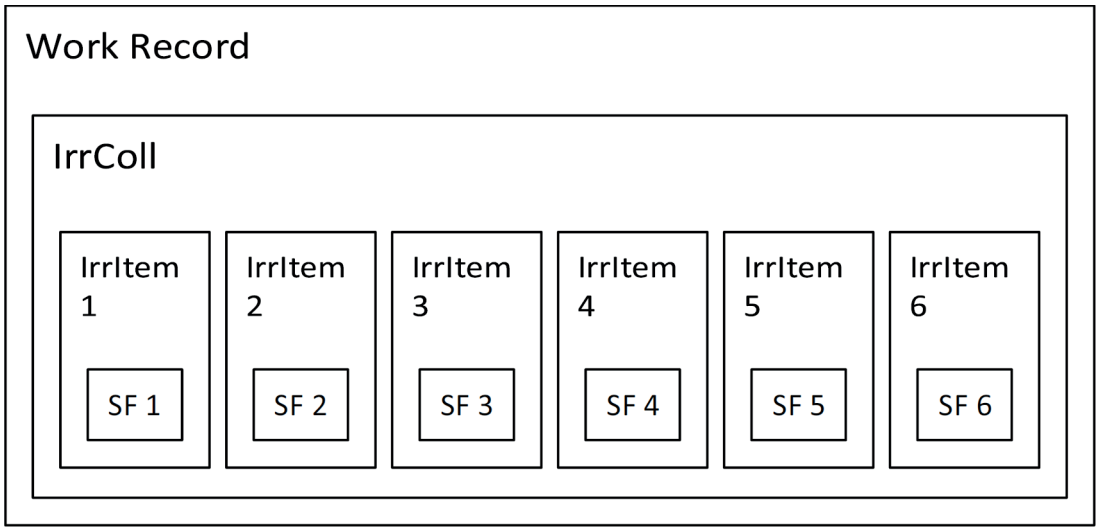


Figure 3 — Concurrent Sets, all Blocks irrigated simultaneously. The rectangles labelled SF 1, SF 2, etc., are the SectionFlow instances corresponding to the Blocks.

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6.1.2 Wheel Lines, Hand Lines and their Component Parts

Wheel Line and Hand Lines are two types of sprinkler irrigation systems (Irrigation, 2011). Figure 4 illustrates the Wheel Line system components that are relevant to 7673-3. For the purposes of this standard, Wheel Line and Hand Lines are equivalent. Irrigation with Wheel Lines typically involves one or more portable lines with multiple sprinklers attached. The lines are moved periodically and typically in a repeating pattern. The line is attached to a hydrant (connection point) and the hydrant is stationary. For some Hand Lines, the hydrants are temporary but their location does not change during the irrigation season.

Each position of the Wheel Line is called a Set. The Set used for Wheel Lines is analogous to Set used by Drip systems described in the previous section. However, Drip systems can have different numbers of Blocks in each Set, Wheel and Hand lines typically have the same number of lines in each Set. In the context of Wheel and Hand lines, Blocks correspond to the area irrigated by a single line when attached to a single hydrant. For example, the system shown in Figure 4 has three Sets and six Blocks.

The following constraints define how to define Wheel Line and Hand Line system's setup information and the irrigation records corresponding to those systems:

— Wheel Lines and Hand Lines shall have one SectionSetup instance for each independently moveable line. For example, the Wheel Line shown in Figure 4 would have two SectionSetup instances.

— The SectionSetup shall not use the InnerDistance or OuterDistance properties.

— The SectionType property of SectionSetup instances for Wheel Lines shall use the "WHEEL_LINE" enumerated value.

— The SectionType property of SectionSetup instance for Hand Lines shall use the "HAND_LINE" enumerated value.

— An IrrItem instance shall contain all of the SectionFlow instances that were irrigated at the same time. Minor variances in start/stop time between lines (i.e., if the lines are moved one at a time by a single person) may be ignored provided the total application depth or volume remains constant at the field level.

— The SectionSetup may use the SpatialFootprint property, however the SpatialFootprint shall cover the entire area irrigated by each Set of that line. For example, in Figure 4 —, the SpatialFootprint for "Line #2" would be the union of the areas labelled "Previous Position", "Current Position", and "Next Position".

— When SectionFlow instances use the PolygonCoverage property, the spatial extent shall correspond to the area covered by the line for that particular Set.

Experienced engineers will note that Wheel Line (and Hand Line) systems are designed such that the sprinkler's throw overlaps with adjacent sprinklers. This overlap ensures uniformity across the whole field. This overlap also prevents defining an unambiguous separation of the irrigated area corresponding to an individual set (i.e., the wetted area from one Set will overlap with other Sets). Within the context of this standard, the PolygonCoverage of all SectionFlow instances which reference the same SectionSetup instance shall correspond to the total area wetted by the line defined in the SectionSetup. This constraint ensures that the union of all the PolygonCoverages (for a particular line) is the total area irrigated by the individual line. The intent of this constraint is to ensure that the application rate and total application depth calculations are consistent at the Set, line, and whole field level.

Figure 4 and Figure 5 illustrates each of these constraints. The system shown in Figure 4 has two lines ("Line #1", and "Line #2"), each having three Sets. A single irrigation event would require moving each line three times. The two lines are always operated simultaneously. Figure 5 shows the WorkRecord's structure for a single wetting of the entire field. The first Set is represented by IrrItem 1, the 2nd by IrrItem 2, etc. The hatching patterns shown in Figure 4 correspond to the hatching in the WorkRecord figure. Since there are three Sets, the IrrColl contains three IrrItem instances. Since both lines are operated simultaneously, each IrrItem contains two SectionFlow instances (labelled "SF 1", "SF 2", etc.), one for each Line.

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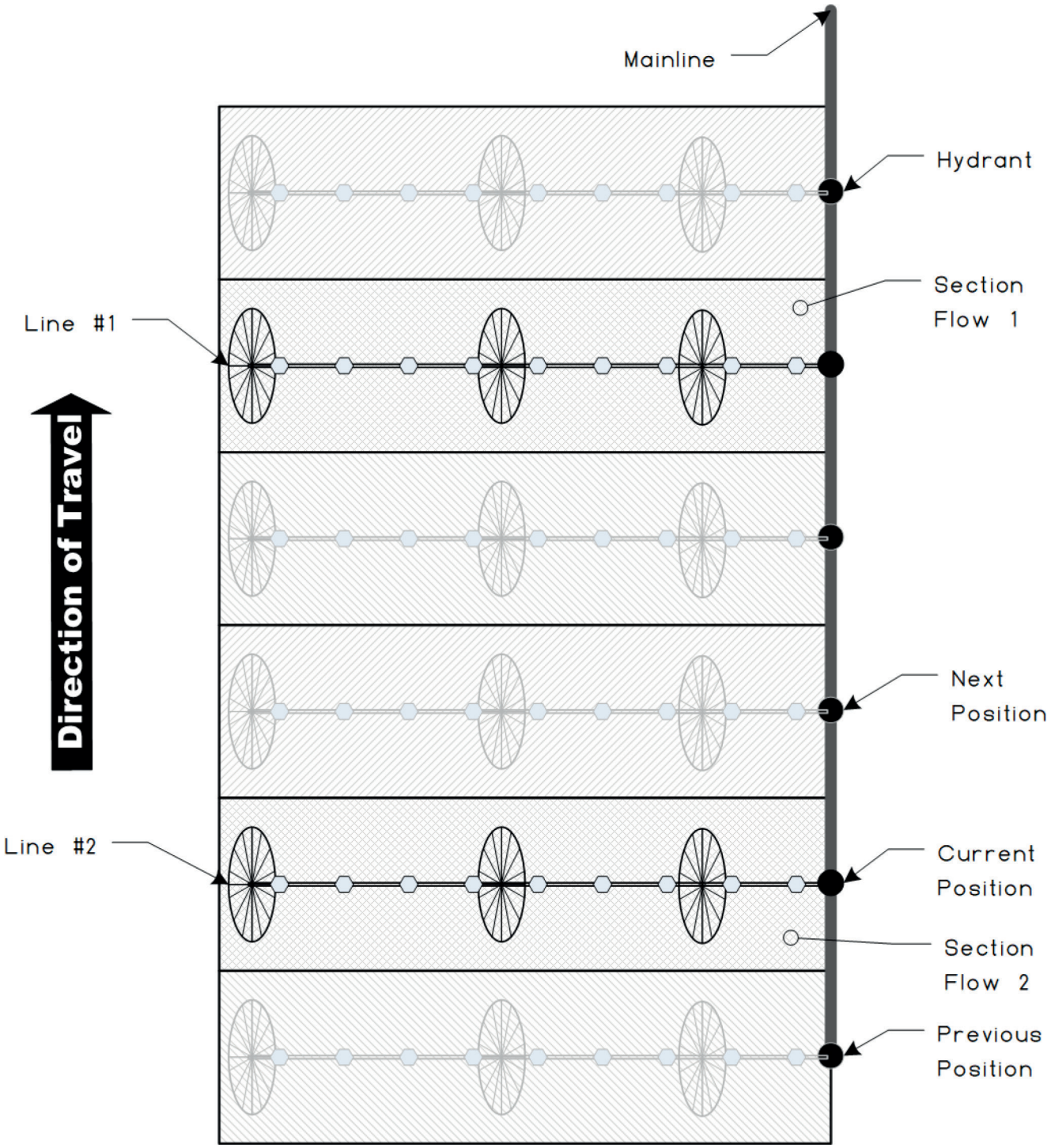


Figure 4 — Schematic view of a Wheel Line system having two lines and three sets.

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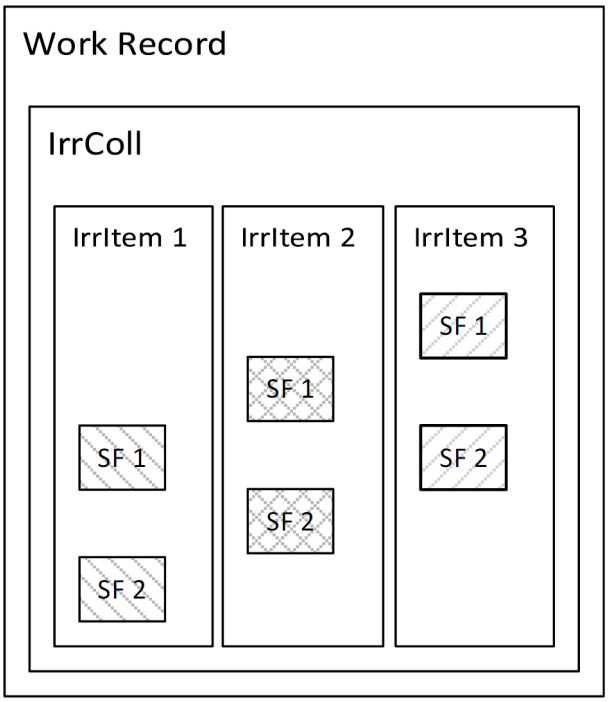


Figure 5 — A WorkRecord corresponding to the Wheel Line shown in the previous figure. The vertical positioning of the SectionFlow boxes is meant to emphasize the temporal ordering of the Sets.

6.1.3 Travelers and their Component Parts

ISO 8244-1 describes Traveller irrigation machines. For the purposes of 7673-3, Travellers includes those systems defined in 8244-1, and systems with the following attributes:

— The emission device(s) is/are mobile during the irrigation event

— The emission device(s) follow a prescribed or planned path during the irrigation

— The emission device(s) move continuously (or periodically with short intervals) during water application

Recent technological advances (low-cost RTK GPS) have enabled semi-autonomous hard-hose traveller irrigation systems. While Traveller systems are generally not automated, newer semi-autonomous systems have performance characteristics that will benefit from standardized data exchange ().

Figure 6 shows the schematic elements of a Traveller system relevant to 7673-3. This figure shows a hard-hose Traveller with attached sprinkler making three passes across a non-rectangular field. Figure 7 shows the WorkRecord structure corresponding to the irrigation shown in Figure 6. The following constraints apply to Traveller systems:

— Each continuous pass shall be represented by a single IrrItem containing a single SectionFlow instance. If the system stops during the pass (intentionally or unintentionally), the pass shall be represented as two separate IrrItem instances.

— The temporal extent of the individual passes shall be documented using the TimeScope property of the SectionFlow's parent IrrItem (see IrrItem for details of the IrrItem class). For example, in Figure 6, the temporal extent of "Pass #1" should be documented by the TimeScope property of "IrrItem 1". If the IrrCollection instance contains a TimeScope property, the TimeScope shall document the overall duration of the irrigation, including both the time spent applying water and the time spent moving the system.

— The spatial extent of the wetted area of each pass shall be documented in one of two ways:

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1. When the same (or nearly the same) machine path is used, the SectionSetup's SpatialFootprint property shall be used to document the spatial extent of an individual pass. Thus, the IrrSetup will have a separate SectionSetup instance for each pass.

2. When the area covered by a pass is a) unique each time the system is used, or b) is documented by GPS data collected during the pass, the SectionFlow's PolygonCoverage property shall contain the spatial extent of the individual pass.

Given the manual nature of Traveller machines, wetted areas often overlap in less-than-optimal ways. This issue is illustrated in Figure 6 by the overlapping hatched areas. It is often impractical to measure the spatial extent *in situ*. As a best practice, the PolygonCoverage (or SpatialFootprint) property may contain an estimated spatial extent of the area covered by the sprinkler.

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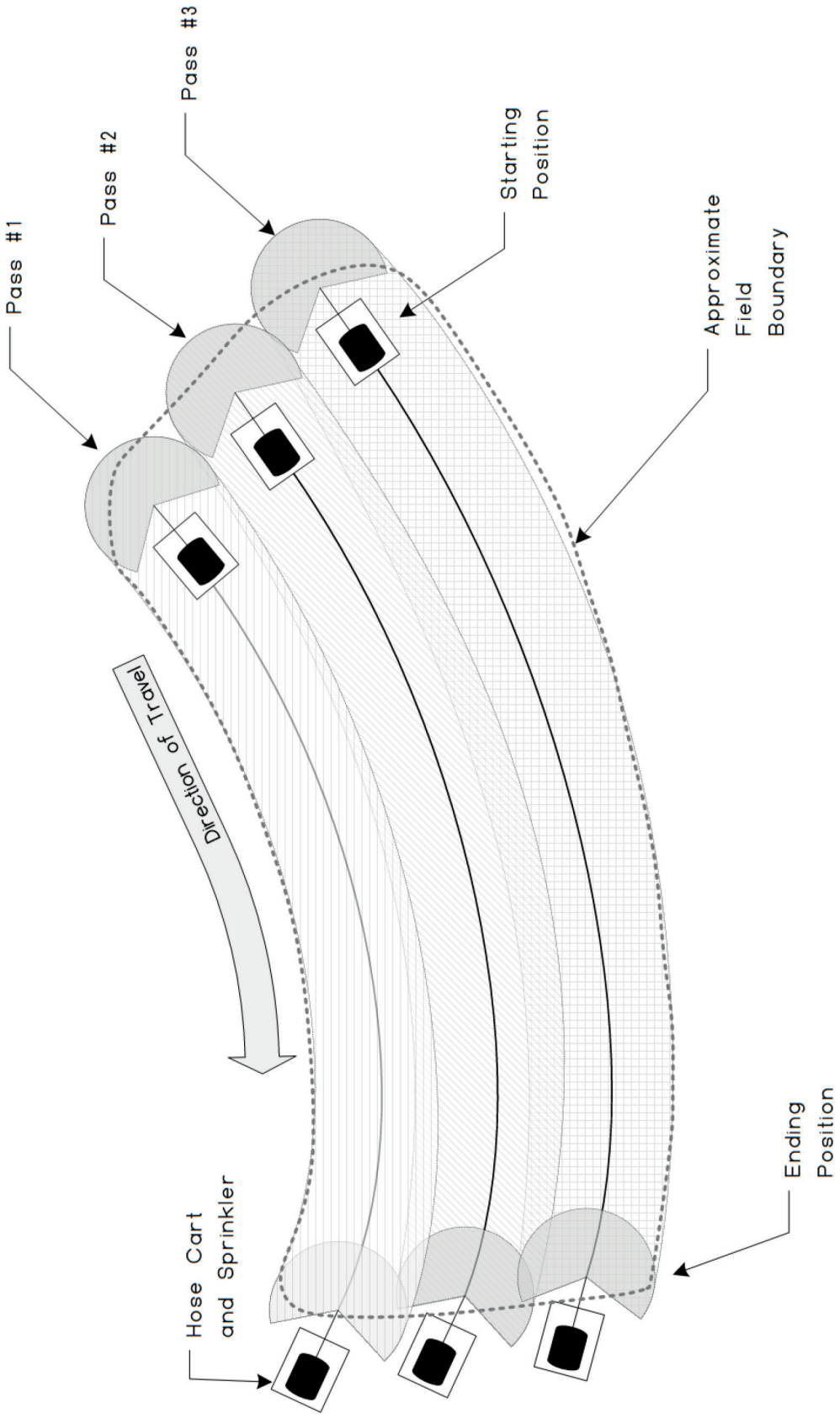


Figure 6 — Traveller schematic diagram

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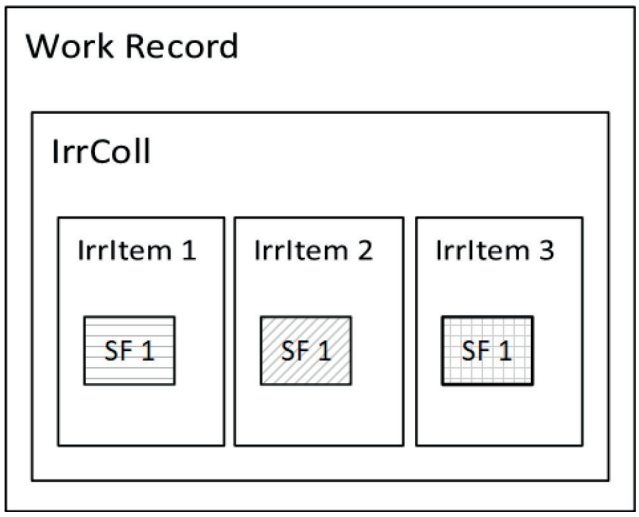


Figure 7 — WorkRecord structure for a Traveller machine

6.1.4 Solid Set

Solid Set systems have been defined in various standards such as EN 13742-1. For the purposes of this standard, a solid set system has the following features:

— The system components (particularly the sprinklers) do not move during or in between irrigations. The system components may move in between irrigation seasons.

— The emission devices are typically sprinklers which distribute water as droplets over distances significantly larger than micro-sprinkler (micro-sprinkler) systems (as defined in ISO24120-3).

These two features differentiate Solid Set systems from Hand Lines (which do move between irrigations), and from drip systems which do not move during or in between irrigations. Solid Set systems may be designed such that portions or subsets of the field can be irrigated; much the same way drip irrigation systems do.

Figure 8 shows a schematic view of a Solid Set system having two sets. The hatched areas delineate the managed area relevant to documenting irrigation. Typically, the field boundary is the managed area. However, given the semi-indeterminate nature of the wetted area (i.e., lack of full sprinkler overlap at the field boundaries), Solid Set systems may use the IrrSetup's SpatialFootprint property to define the field boundary, and the SectionSetup's SpatialFootprint property to define the spatial extent of the wetted area. When both IrrSetup.SpatialFoorptint and SectionSetup.SpatialFootprint are used, the IrrItem.SectionFlow's Vol and Depth properties shall refer to the area defined by SectionSetup.SpatialFootprint.

Figure 9 shows a WorkRecord document structure for a single irrigation by the system shown in Figure 8 . The hatching in the section flow boxes (labelled "SF 1", and "SF 2") corresponds to the hatched areas in Figure 8. Solid Set systems shall use the same definition of Set and Block as used by Drip Systems (see Drip Irrigation Systems and their Component Parts).

The following constraints shall be applied to Solid Set systems:

— The SetupData.IrrSystem.SystemType property shall use the SOLID_SETenumerated value

— The spatial extent of individual sets shall be documented using the SectionSetup.SpatialFootprint property.

— The temporal extent of individual sets shall be documented by the IrrItem's TimeScope property

— When multiple sets are irrigated simultaneously, the SectionFlow instances shall be grouped in the same IrrItem instance.

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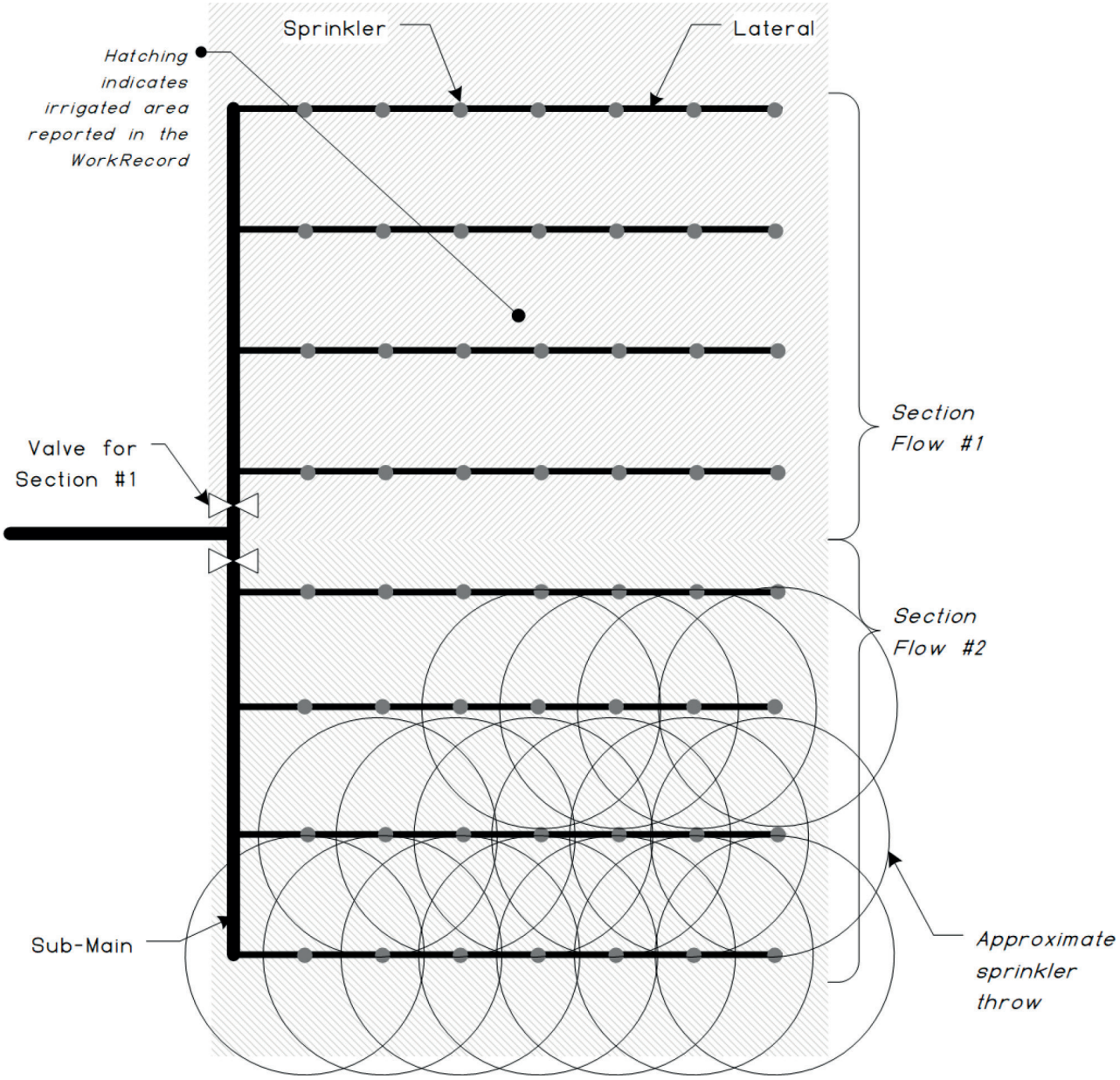


Figure 8 — Schematic view of a Solid Set irrigation system having two Sets.

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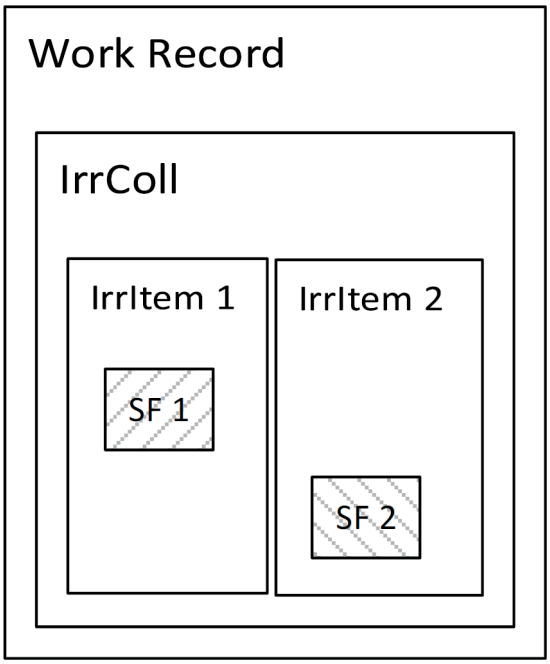


Figure 9 — Sample document structure for a Solid Set system

6.1.5 Pivot Irrigation Systems and their Component Parts

With a centre pivot irrigation system, water is applied by sprinklers that cover some length of the total system. Depending on the abilities of the irrigation system, the sprinklers may be controlled individually or as a group of sprinklers. This group of sprinklers or contiguous wetted portion is called a Section (3.23). If the group of sprinklers covers the full length of the irrigation system, there is one section and its inner distance is the distance from the pivot centre to the first sprinkler or innermost wetted area. Similarly, the outer distance is the distance from the pivot centre to the last sprinkler or outermost wetted area. The geometric interpretation of the Section is illustrated in Figure 10. When there are multiple groups of sprinklers, each section is defined as the distance of the first sprinkler or wetted area of the section (measured from the pivot's centre) to the distance of the last sprinkler or wetted area of the section. Sections are a basic unit of water delivery in this standard. Pivots, and Linear Move, do not use the Set and Block concepts.

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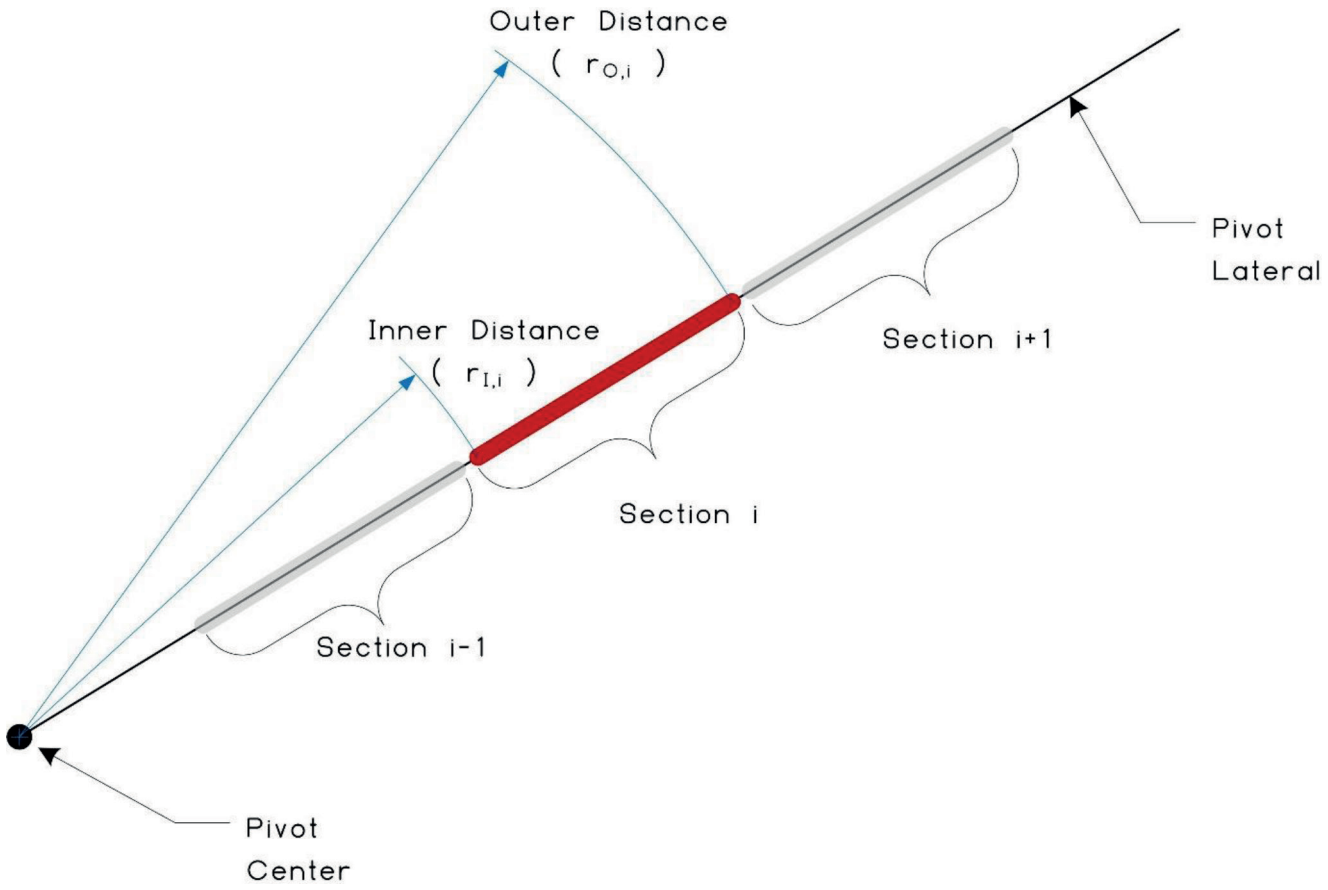


Figure 10 — Schematic illustration of a Section class

The Section concept enables the description of the physical and conceptual partitioning of an irrigation system. The physical partitioning applies to the obvious relation of a single section describing a single span of a pivot. The Section class can be used to describe more than a single span. It is entirely valid to have a single Section describe an entire pivot or an individual sprinkler. This flexibility is how Sections, combined with the IrrItem, can document nearly any type of irrigation application. It is important to note, however, that Section definitions are intended to support documenting water applications that differ along the length of the system. Adjacent section definitions that are identical in all respects except position do not enable any additional expository benefit and will increase reporting burden. If a pivot is defined with two sections that both apply the same depth of water each time they are used then the resulting Work Orders, and Work Records will contain unnecessary duplication.

The Section abstraction is not meant as a direct analogue of pivot architecture. Instead, the abstraction is convenient for pivots and adequate for any other system type. The Section definitions enable separation of the physical description of the system from the description of the system's use. The intent here is to support pivot systems in a convenient manner but also be flexible enough for most other system types. The Section abstraction will still be relevant for more disparate system geometries because the definition includes an optional geometric specification for the irrigated area.

For non-radial areas, the Section class also includes a SpatialFootprint object that can be used to describe any physical partitioning of the irrigated area. This is achieved using the SpatialScope class defined in ISO 7673-1.

It is important to note that the radial specification does not, by itself, specify a particular location or area. Figure 11 shows how the definition of a section in terms of distances from a center of rotation translates into an irrigated area when the system rotates. Figure 12 illustrates how the IrrItem, SectionFlow, and the Section together specify an amount of water applied to a particular area.

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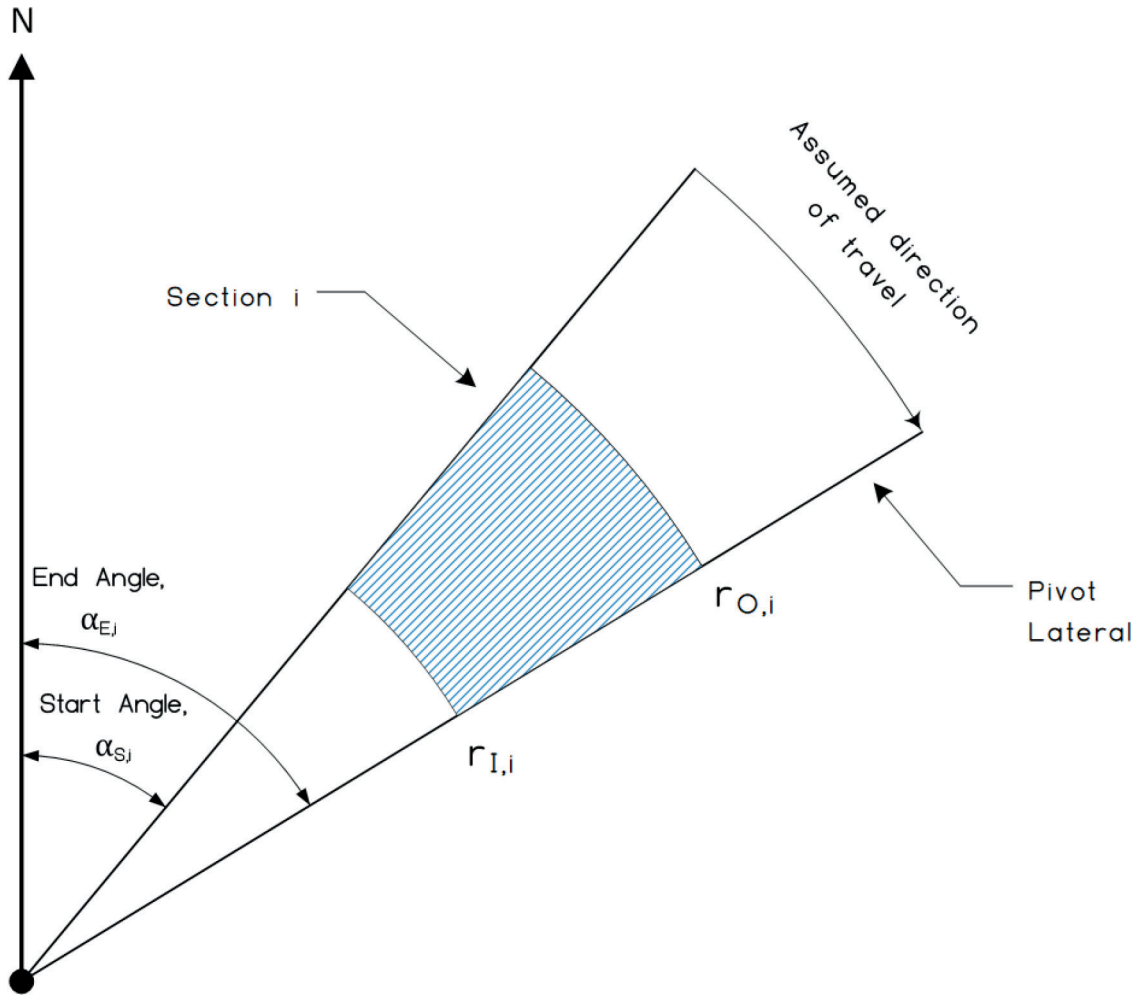


Figure 11 — Schematic view of the area subtended by a Section moving from Start Angle to End Angle

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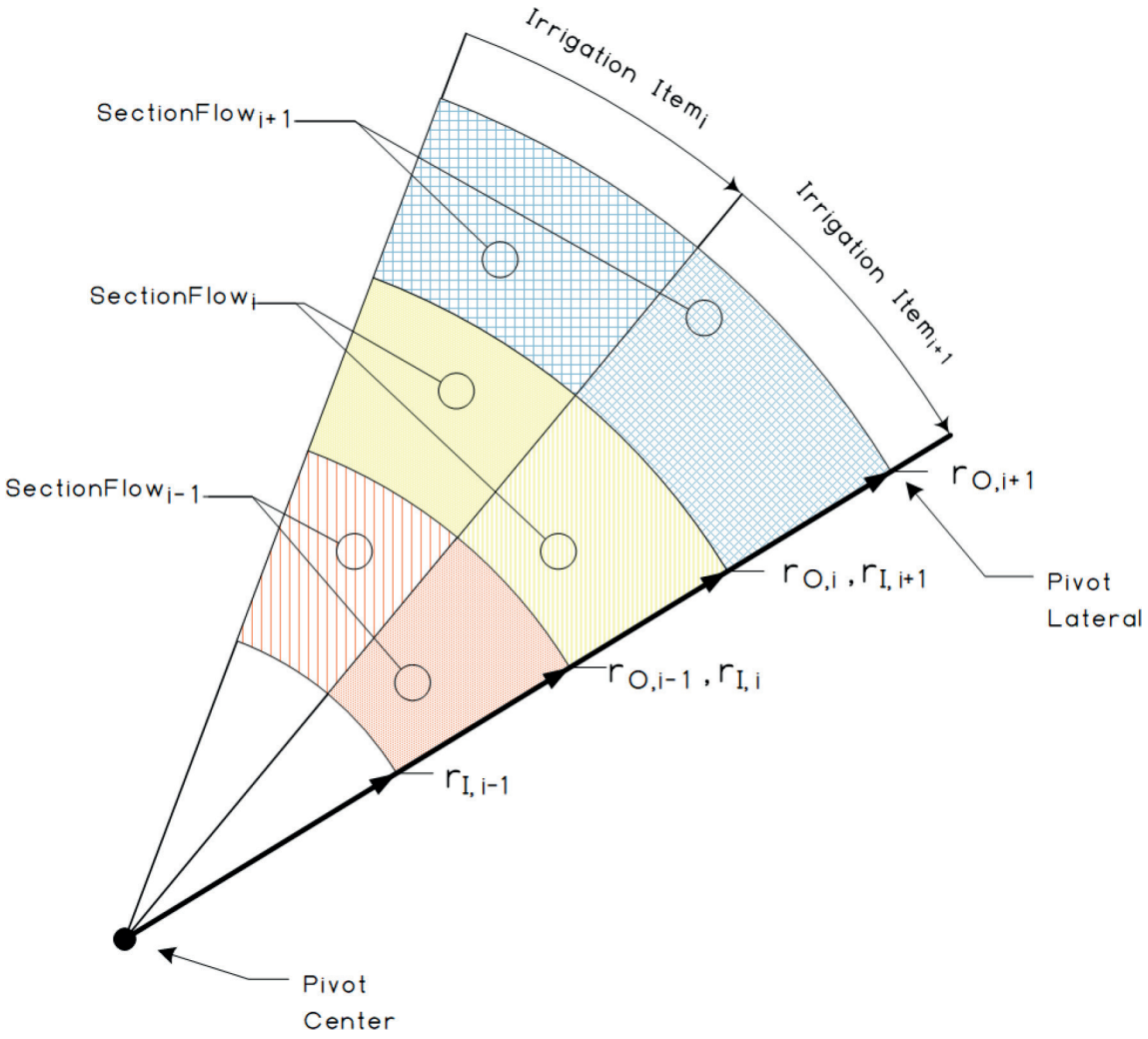


Figure 12 — Six SectionFlow areas associated with three adjacent Section definitions and two adjacent IrrItems.

When applying water with a center pivot irrigation system knowing how much water was applied and where it was applied is essential. With a single section, the area can be calculated by taking the area of the entire circle multiplied by the percentage that was covered as described by the start and end angles. To find the area covered by a specific section use the equation is described below.

$$A_{i,j} = \left(\frac{\alpha_{i,j} - a_{i,j}}{2\pi} \right) \left(\pi r_{O,i}{}^2 - \pi r_{I,i}{}^2 \right) = \left(\frac{\alpha_{e,j} - \alpha_{e,j}}{2} \right) \left(r_{O,i}{}^2 - r_{I,i}{}^2 \right) \quad (1)$$

where

$A_{i,j}$ The area irrigated by section i during time interval j

α An angle of rotation, measured clockwise from a reference (e.g., north)

r A radius (i.e., system length), measured with respect to the centre of rotation.

Clauses Document Structure and Irrigation Records contain examples of the document structure for Pivot systems.

Endguns (3.8) extend the outer range of a pivot system. These devices are often but not always pressurized by a supplemental booster pump. In some cases, the endgun is only pressurized when the pivot is near the corner of a square or rectangular field, and the added range enables irrigation over an otherwise unirrigated

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area. While it is possible to install pressure regulation downstream of the booster pump, this practice is not universally applied. On fields where groundwater levels vary over a season, the pressure and flowrate of the pivot also vary. This seasonal change in pressure and flow also create a seasonal change in throw distance and flowrate of the endgun, resulting in a seasonally variable irrigated area. This variation of irrigated area is often small enough that operators ignore it. However, as water resources become more scarce, particularly groundwater, it becomes necessary to more accurately quantify irrigation applications. To that end, ISO 7673-3 enables specification of endgun use in three ways.

When endguns are present on a pivot, one of the following three scenarios shall be used:

1. **Complete specification of application depth and spatial extent**. The computational burden is placed on the data producer. In this scenario, the data producer must specify the spatial extent in each WorkRecord.

2. **Partial specification of wetted area**. In this scenario, the data producer uses an assumed throw length obtained from the setup, and reports depth/volume of application in the WorkRecords. Data producers may use multiple IrrSetup instances, with different TimeScopes and varying SectionSetup instances, to increase the accuracy of the spatial extent. When the endgun is only used in the corners, the data producer shall use a polygon to specify the wetted area. When the endgun is used throughout the field, the data producer shall use the SectionSetup.innerDistance and SectionSetup.outerDistance to specify the wetted area.

3. **Implicit specification of wetted area and application depth**. The computational burden for estimating these quantities is placed on the data consumer. The sender shall include SectionFlow instances that contain only id values. In this scenario, the setup records must contain an instance of the EndgunSetup class, which the data receiver shall use, together with reported pressure data, to compute the estimated wetted area and the depth of application.

Table 3 summarizes the characteristics of these three scenarios.

— The column titled "**Who determines throw and depth?**" specifies whether the data producer or the data receiver computes the depth of application and the wetted area.

— The column titled "**Pressure data required?**" indicates if pressure information must be included in the WorkRecord.

— The column titled "**Spatial extent**" indicates whether the wetted area is specified for each irrigation event, or assumed constant

— The column titled "**EndgunSetup required?**" indicates if the setup document must contain the EndgunSetup object instance and whether that instance must be sent to the data consumer.

— The column titled "**SectionSetup contains ...**" indicates what information is required in the SectionSetup instance.

— The column titled "**SectionFlow contains ...**" indicates what information is required in the SectionFlow instances appearing in WorkRecords.

Details of the EndgunSetup data are specified in Clauses EndgunSetup, TabularValues, and TableEntry.

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