An Electronic Decision Support System to Determine the Site-Specific Fitness-for-Use of Irrigation Water

by

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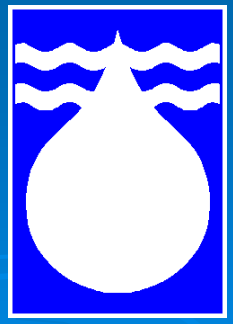
and N Benade



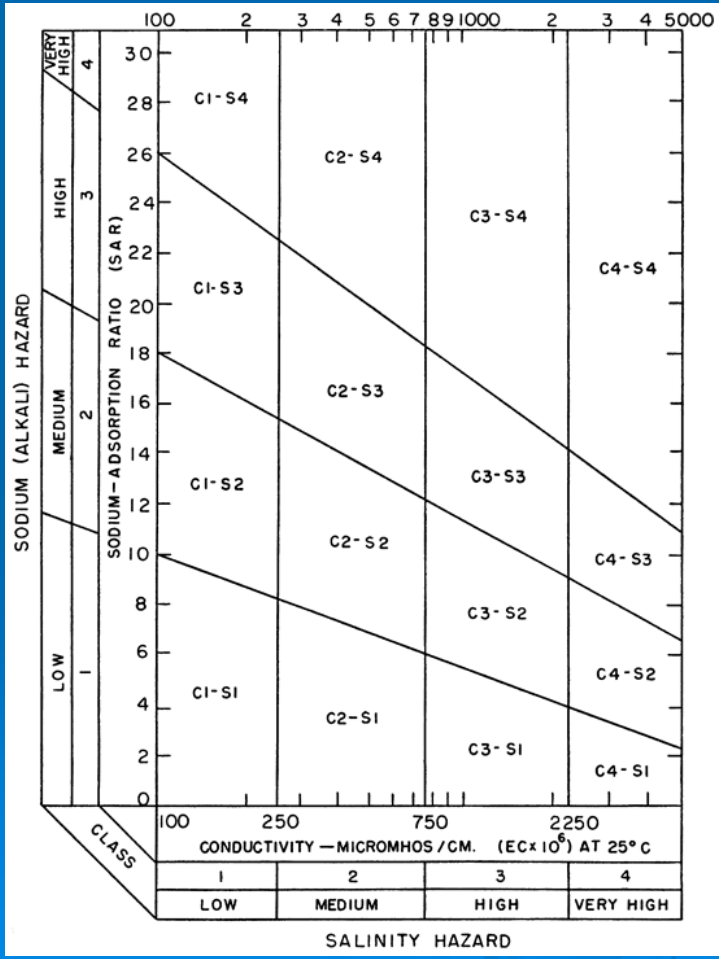
Outline of Presentation

- Background
- Approach followed to develop the DSS with which to assess the site specific fitness-for-use of irrigation water
- Examples of the DSS Input and Output
- Conclusions

WQ Guideline Development in SA

- DWS published the first SA WQ Guidelines in 1993 with a revision in 1996
- Intended primarily to assist with establishing water quality requirements in water bodies and improved management
- Guidelines also found application in evaluation of fitness for use
- Perception that the 1996 were out of date led to a needs assessment by panel of experts. Report published in 2008.

Several Guideline Documents are Currently in Use



- Irrigation water quality classification diagram by US Salinity Laboratory Staff (1954)

SA Water Quality Guidelines (1996)

EC Range (mS/m)	Crop Yield
Target Water Quality Range ***< 40***	***Should ensure that salt-sensitive crops can be grown without yield decreases when using low frequency irrigation systems. A leaching fraction of up to 0.1 may be required and wetting of the foliage of sensitive crops should be avoided***
40 - 90	A 95 % relative yield of moderately salt-sensitive crops can be maintained by using a low-frequency irrigation system. A leaching fraction of up to 0.1 may be required and wetting of the foliage of sensitive crops should be avoided
90 - 270	A 90 % relative yield of moderately salt-tolerant crops can be maintained by using a low-frequency application system. A leaching fraction of up to 0.15 may be required and wetting of the foliage of sensitive crops should be avoided
270 - 540	A 80 % relative yield of moderately salt-tolerant crops can be maintained provided that a high-frequency irrigation system is used. A leaching fraction of up to 0.2 may be required and wetting of the foliage of sensitive crops should be avoided
> 540	These waters can still be used for irrigation of selected crops provided sound irrigation management is practised and yield decreases are acceptable. However, the management and soil requirements become increasingly restrictive and the likelihood of sustainable irrigation decreases rapidly

Why revise the current guidelines?

- The changed approach to WQ management embodied in the 'new' 1998 National Water Act, calls for compatible Guidelines
- 'Risk' envisaged to provide a common philosophical basis for decision making
- Current guidelines are very generic in nature – no site specificity (don't consider climate, soil, crop, irrigation management)
- Focussed on inorganic constituents (e.g. COD, nutrients, pesticides are not considered)
- Current guidance are unambiguous (in practice uncertainty)

Execution of the Project

- Assemble a strong multi-disciplinary team to undertake the research and development
- Soil Scientists
- Crop Production Experts
- Microbiologist
- Pesticide Expert
- Computer Programmer and Modellers
- Project Advisors

Project Team

Name	Affiliation	Capacity
Prof JG Annandale	Univ Pretoria	Project Leader
Dr JM Dabrowski	CSIR	Advisor
Prof CC du Preez	Univ Free State	Advisor
Dr SHJ Jooste	DWS	Advisor
Dr JP Nell	ARC	Advisor
Dr N Benade	NB Systems	Principal Researcher
Mr HM du Plessis	Univ Pretoria	Principal Researcher
Dr J H Barnard	Univ Free State	Researcher
Dr NH Rodda	Univ KZN	Researcher
Dr M van der Laan	Univ Pretoria	Researcher
Ms L Madiseng	Univ Pretoria	Student

Development of the DSS

- Decide on water constituents to consider in the DSS
- Identify suitability indicators to use in assessing irrigation water fitness-for-use
- Determine which factors and water constituents affect each suitability indicator
- Integrate these factors using steady state (Tier 1) and dynamic modelling (Tier 2) approaches to quantify the effect of water constituents on suitability indicators
- Design and develop the electronic DSS

Fundamental Differences with Other Guidelines

- Risk based
- Allow for greater site-specificity
- Primarily a software based Decision Support System (rather than text based guidelines)
- Water quality assessed at different levels of sophistication (Tiers)

The DSS is used to:

1. Evaluate the fitness-for-use of a specific water (Irrigator, water analysis laboratory). For what can this water be used? What are the implications for soil quality and crop yield when using this water?

2. Establish (set) water quality requirements that will meet the needs of irrigation water users (Water resource manager at DWS). What quality water is required for irrigation?

Water Constituents for DSS

Macro ions	Biological parameters	General
Calcium	**Human and animal**	pH
Carbonate / Bicarbonate	**pathogens (*E. coli*)**	Corrosion
Chloride	**COD**	Clogging
Magnesium		**Suspended solids**
Sodium		
Sulphate		

Salinity and sodicity	Nutrients	Pesticides
Electrical conductivity	Nitrogen	**Atrazine**
Sodicity (SAR)	**Phosphorus**	
	Potassium	

Trace elements		
Aluminium	Copper	Molybdenum
Arsenic	Fluoride	Nickel
Beryllium	Iron	Selenium
Boron	Lead	Uranium
Cadmium	Lithium	Vanadium
Chromium(VI)	Manganese	Zinc
Cobalt	**Mercury**	

Aspects Affected by Irrigation Water Composition

- Soil Quality
- Crop Yield & Quality
- Irrigation Equipment

Selected Irrigation Water Suitability Indicators

Soil Quality	Crop Yield & Quality	Irrigation Equipment
Root zone salinity	Crop yield	Scaling
Soil permeability	Leaf scorching	Corrosion
Excessive C loading	Microbial contamination	Clogging of drippers
Trace element accumulation / release to crops	Nutrient effects on crop yield and quality	
	Effect of pesticides on crop yield	

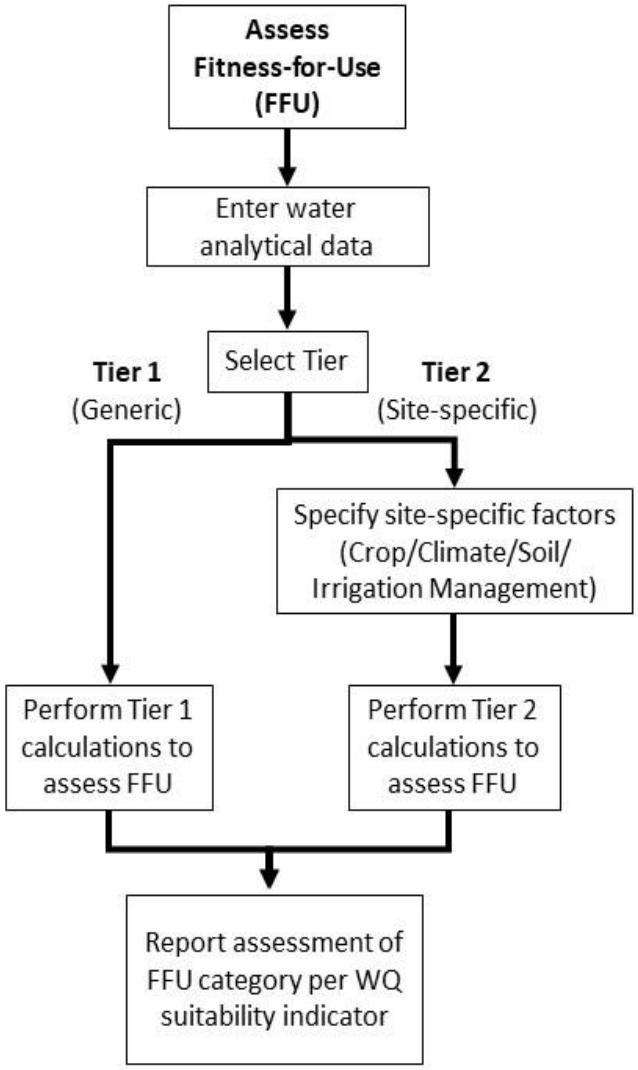
Effect of Water Constituents on Suitability Indicators

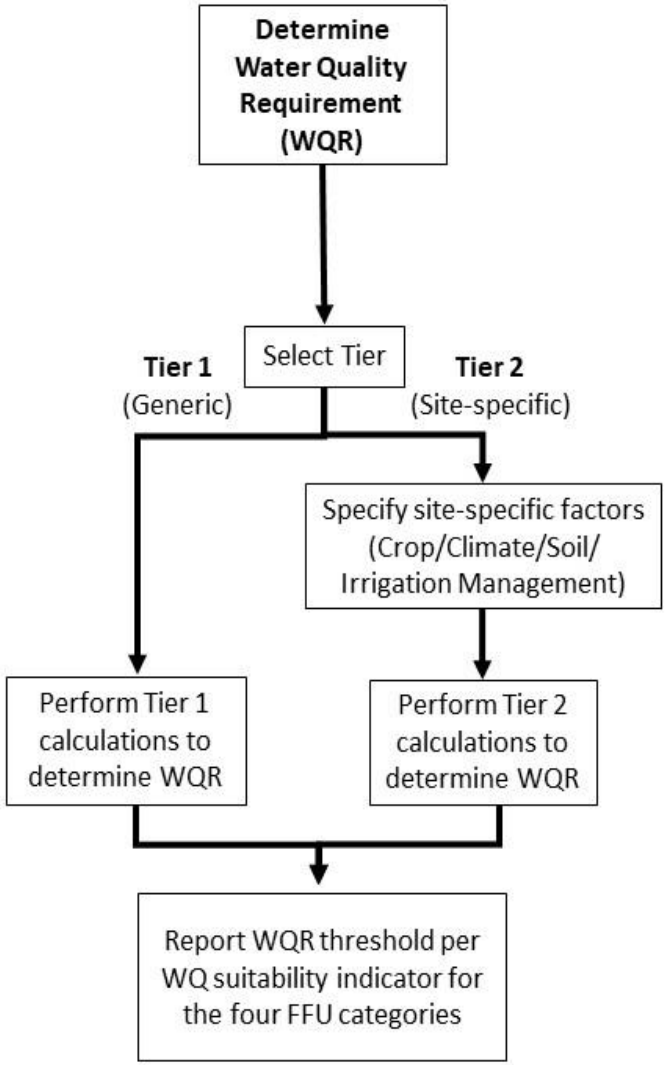
	Soil quality		Crop yield and quality			Irrig Equip	
Major Constituents	Root zone salinity	Soil permeability	Crop yield	Specific ion tolerance	Leaf scorching	Clogging	Corrosion
Bicarbonate					X	X	X
Calcium		X				X	
Chloride			X	X	X		X
Magnesium		X	X				
Sodium		X	X	X	X		
Sulphate	X						
Electrical Conductivity	X	X	X		X		X

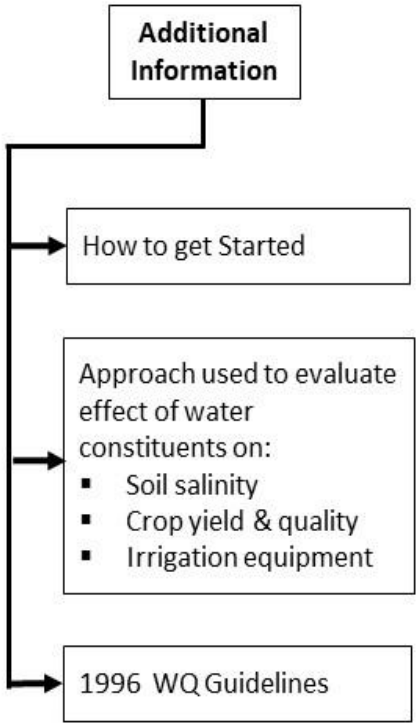
Fitness-for-Use Classes

Ideal	NO IMPAIRMENT to the Fitness-for-Use of the water for its Intended use
Acceptable	SOME IMPAIRMENT to the Fitness-for-Use of the water for its Intended use
Tolerable	INCREASINGLY UNACCEPTABLE IMPAIRMENT to the Fitness-for-Use of the water for its Intended use
Unacceptable	UNACCEPTABLE IMPAIRMENT to the Fitness-for-Use of the water for its Intended use

DSS Structure







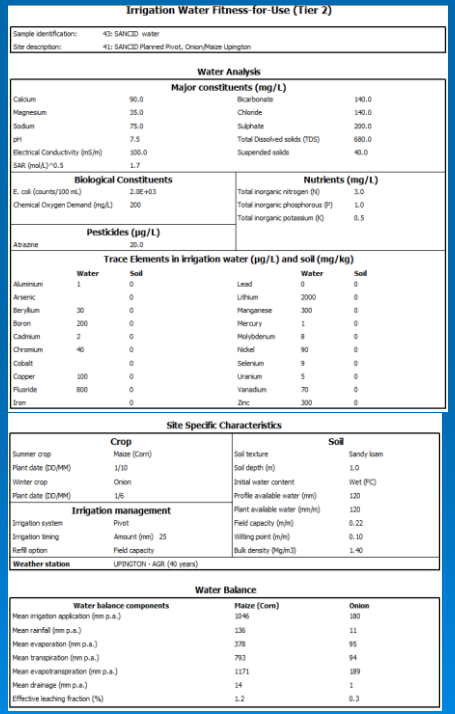
Output

Water and Site Properties

Soil Quality

Crop Yield and Quality

Irrigation Equipment



Irrigation Water Fitness-for-Use (Tier 2)

Sample identification:	43: SANCID water
Site description:	41: SANCID Planned Pivot, Onion/Maize Upington

Water Analysis

Major constituents (mg/L)

Calcium	90.0	Bicarbonate	140.0
Magnesium	35.0	Chloride	140.0
Sodium	75.0	Sulphate	200.0
pH	7.5	Total Dissolved solids (TDS)	680.0
Electrical Conductivity (mS/m)	100.0	Suspended solids	40.0
SAR (mol/L)^0.5	1.7		

Biological Constituents

E. coli (counts/100 mL)	2.0E+03
Chemical Oxygen Demand (mg/L)	200

Nutrients (mg/L)

Total inorganic nitrogen (N)	3.0
Total inorganic phosphorous (P)	1.0
Total inorganic potassium (K)	0.5

Pesticides (µg/L)

Atrazine	20.0

Trace Elements in irrigation water (µg/L) and soil (mg/kg)

	Water	Soil		Water	Soil
Aluminium	1	0	Lead	0	0
Arsenic		0	Lithium	2000	0
Beryllium	30	0	Manganese	300	0
Boron	200	0	Mercury	1	0
Cadmium	2	0	Molybdenum	8	0
Chromium	40	0	Nickel	90	0
Cobalt		0	Selenium	9	0
Copper	100	0	Uranium	5	0
Fluoride	800	0	Vanadium	70	0
Iron		0	Zinc	300	0

Site Specific Characteristics

Crop		Soil	
Summer crop	Maize (Corn)	Soil texture	Sandy loam
Plant date (DD/MM)	1/10	Soil depth (m)	1.0
Winter crop	Onion	Initial water content	Wet (FC)
Plant date (DD/MM)	1/6	Profile available water (mm)	120
Irrigation management		Plant available water (mm/m)	120
Irrigation system	Pivot	Field capacity (m/m)	0.22
Irrigation timing	Amount (mm) 25	Wilting point (m/m)	0.10
Refill option	Field capacity	Bulk density (Mg/m3)	1.40
Weather station	UPINGTON - AGR (40 years)		

Water Balance

Water balance components	Maize (Corn)	Onion
Mean irrigation application (mm p.a.)	1046	180
Mean rainfall (mm p.a.)	136	11
Mean evaporation (mm p.a.)	378	95
Mean transpiration (mm p.a.)	793	94
Mean evapotranspiration (mm p.a.)	1171	189
Mean drainage (mm p.a.)	14	1
Effective leaching fraction (%)	1.2	0.3

TIER 1: FITNESS-FOR-USE

Effect on Soil Quality when irrigated with 1000 mm p.a.

	Fitness-for-Use Class	Predicted equilibrium soil cover salinity (dS/m)
Root Zone Salinity	Ideal	0 - 350
	Acceptable	350 - 670
	Tolerable	670 - 1000
	Unacceptable	>1000

	Fitness-for-Use Class	Degree of sodium permeability	Classification (reduction of the impact on soil permeability as manifested by sodicity)	
			Surface infiltration	Soil Hydraulic Conductivity
Soil Permeability	Ideal	None		None
	Acceptable	Slight	Slight	
	Tolerable	Moderate		
	Unacceptable	Severe		

	Fitness-for-Use Class	Dissolved Carbon Load (Tons per year)	Dissolved Carbon Trend (Tons per year)
Dissolved Carbon Loading	Ideal	0 - 50	
	Acceptable	51 - 100	Fall
	Tolerable	101 - 300	
	Unacceptable	>300	

	Fitness for Use Class	Number of years of 1000 mm irrigation before Trace Elements reach unacceptable threshold in topsoil			
Trace Element Accumulation	Ideal	>300 years to maximum accumulation threshold			
	Acceptable	180 to 300 years to maximum accumulation threshold			
	Tolerable	100 to 180 years to maximum accumulation threshold			
	Unacceptable	<100 years to maximum accumulation threshold			

Trace Element	Soil Accumulation Threshold (mg/kg)	No of years for each Soil Accumulation Threshold	Trace Element	Soil Accumulation Threshold (mg/kg)	No of years for each Soil Accumulation Threshold
As	20		Li	70	
Be	8		Mn	900	
Bo	100		Hg	1	
Cd	8		Mo	5	
Cr	90	178	Ni	100	
Co	25		Se	10	
Cu	100		U	5	
F	500		Va	50	
Fe	2000		Zn	300	90
Pb	100				

TIER 1: FITNESS-FOR-USE EVALUATION

Effect on Yield and Quality of a Generic Sensitive Crop Irrigated with 1000 mm p.a.

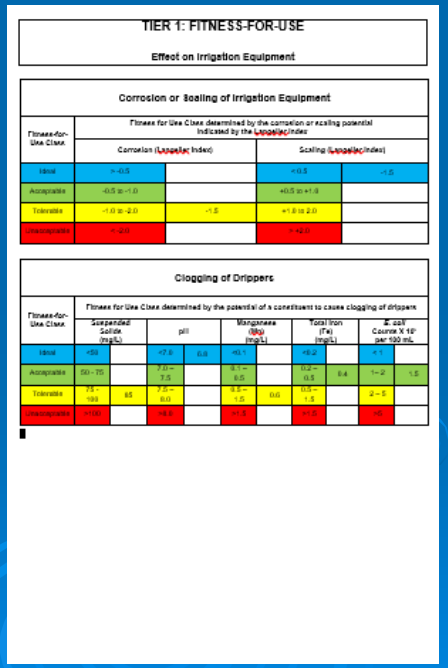
	Fitness-for-Use Class	Relative crop yield (%)	Predicted relative crop yield (%) as affected by:			
			Salinity (EC)	Boron (B)	Chloride (Cl)	Sodium (Na)
Root Zone Effects	Ideal	90 - 100		95		
	Acceptable	80 - 90	87		85	
	Tolerable	70 - 80				70
	Unacceptable	<70				

	Fitness-for-Use Class	Degree of leaf scorching	Degree of leaf scorching under sprinkler irrigation caused by:	
			Chloride (Cl)	Sodium (Na)
Leaf scorching when wetted	Ideal	None	None	
	Acceptable	Slight		
	Tolerable	Moderate		Moderate
	Unacceptable	Severe		

	Fitness-for-Use Class	Contribution to estimated N P K removal by crop	% of estimated N P K removal at harvest and amount applied through irrigation, acknowledging that high nutrient concentrations may impact development of sensitive crops					
			Nitrogen (N)		Phosphorous (P)		Potassium (K)	
			% removed	Applied (kg/ha)	% removed	Applied (kg/ha)	% removed	Applied (kg/ha)
Contribution to N P K removal by generic sensitive crop	Ideal	<10%	e.g. 9	e.g. 10	e.g. 2	e.g. 2		
	Acceptable	10 – 30%					e.g. 20	e.g. 5
	Tolerable	30 – 50%						
	Unacceptable	>50%						

	Fitness-for-Use Class	Excess infections per 1000 p.a.	Predicted excess infections per 1000 p.a.
Microbial Contamination	Ideal	<1	
	Acceptable	1 - 5	2
	Tolerable	5 - 10	
	Unacceptable	>10	

	Fitness-for-Use Class	Qualitative degree of crop damage	Qualitative estimate of crop damage
Qualitative Atrazine Damage	Ideal	None	
	Acceptable	Slight	Slight
	Tolerable	Moderate	
	Unacceptable	Severe	



TIER 1: FITNESS-FOR-USE

Effect on Irrigation Equipment

Corrosion or Scaling of Irrigation Equipment

Fitness-for-Use Class	Fitness for Use Class determined by the corrosion or scaling potential indicated by the Langelier Index			
	Corrosion (Langelier Index)		Scaling (Langelier Index)	
Ideal	> -0.5		< 0.5	< 1.5
Acceptable	-0.5 to -1.0		+0.5 to +1.0	
Tolerable	-1.0 to -2.0	< 1.5	+1.0 to 2.0	
Unacceptable	< -2.0		> +2.0	

Clogging of Drippers

Fitness-for-Use Class	Fitness for Use Class determined by the potential of a constituent to cause clogging of drippers									
	Suspended Solids (mg/L)		pH		Manganese (Mn) (mg/L)		Total Iron (Fe) (mg/L)		E. coli Counts X 10^ per 100 mL	
Ideal	<50		<7.4	6.8	<0.1		<0.2		< 1	
Acceptable	50 - 75		7.0 – 7.5		0.1 – 0.5	0.4	0.2 – 0.5	0.4	1 – 2	1.5
Tolerable	75 - 100	65	7.5 – 8.0	0.6	0.5 – 1.5		0.5 – 1.5		2 – 5	
Unacceptable	>100		>8.0		>1.5		>1.5		>5	

DSS Home Page

South African Water Quality Guidelines (version 8 Nov 2018)

Tools Help

IWQG Exit

Irrigation Water Quality Descision Support System (Beta Version 1.1)

DISCLAIMER

This descision support system was developed to provide guidance on the effect of irrigation water quality on soil quality, crop yield and quality, and irrigation equipment.

Extreme attention to detail has been given to ensure that calculation procedures in this model are sound.

Nevertheless, the authors, the University of Pretoria and the Water Research Commission will not accept liability for any damage or loss suffered as a result of the use of this model.

Accept & Proceed | Decline & Exit

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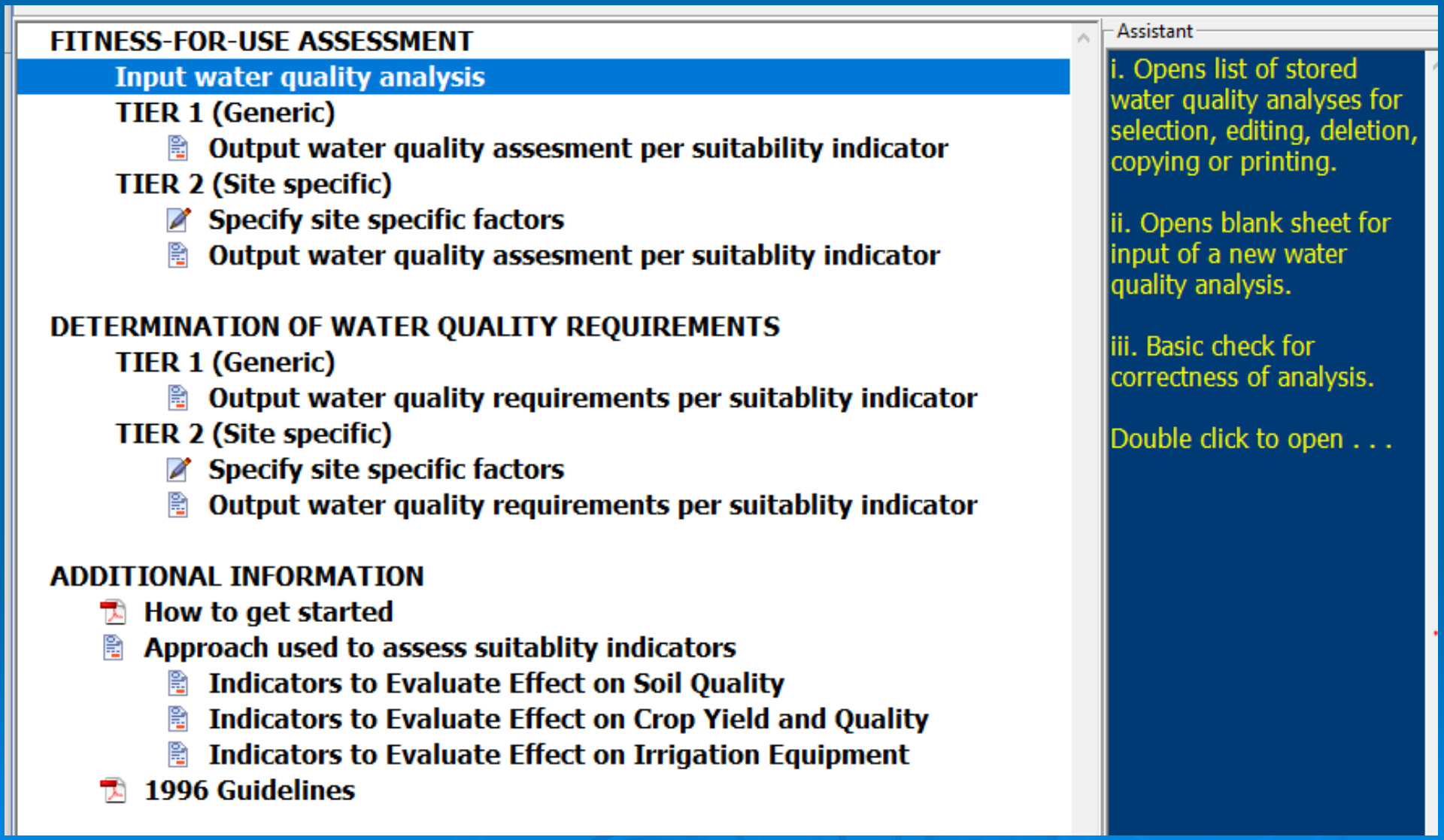
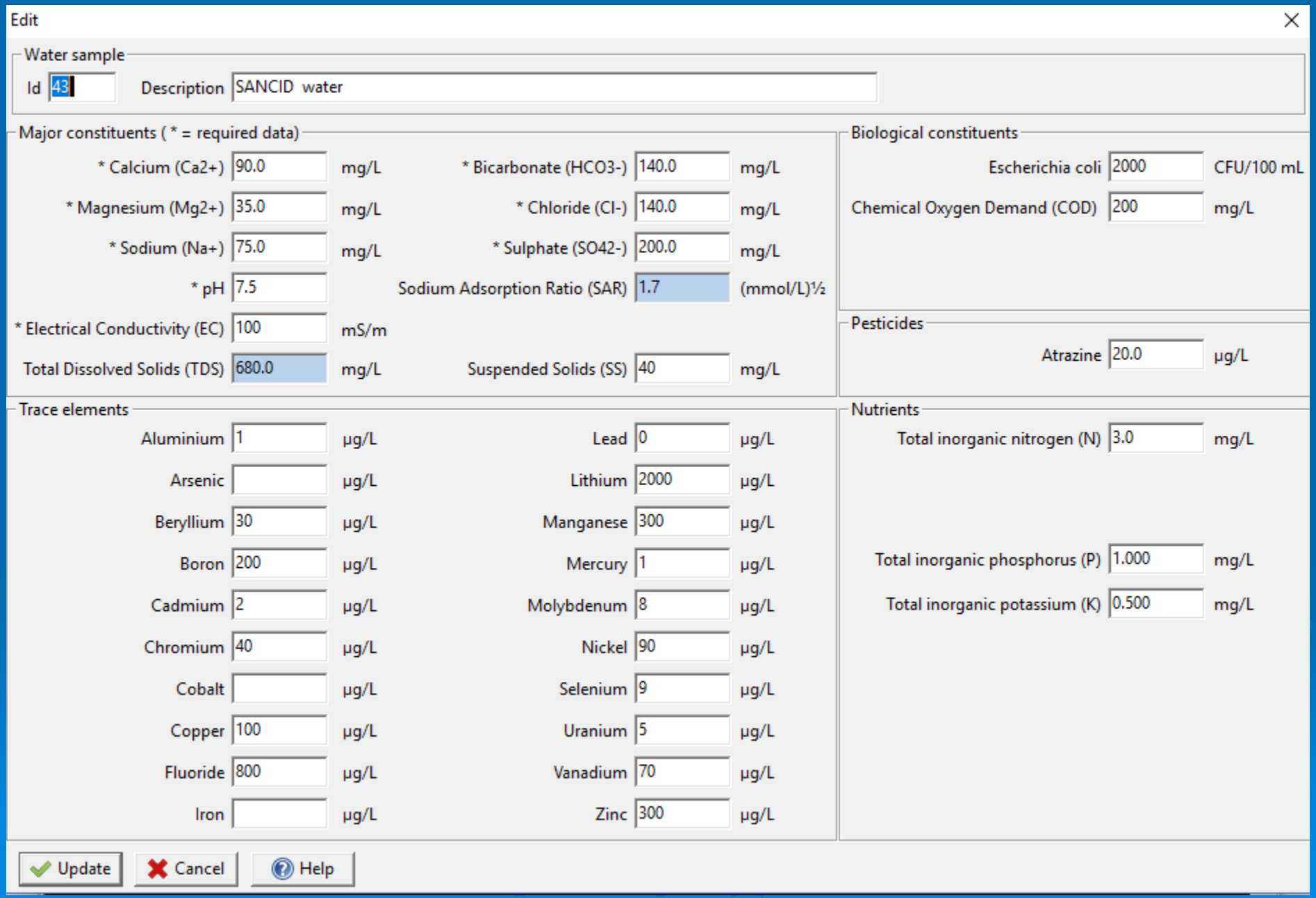


Input / Edit Water Analysis



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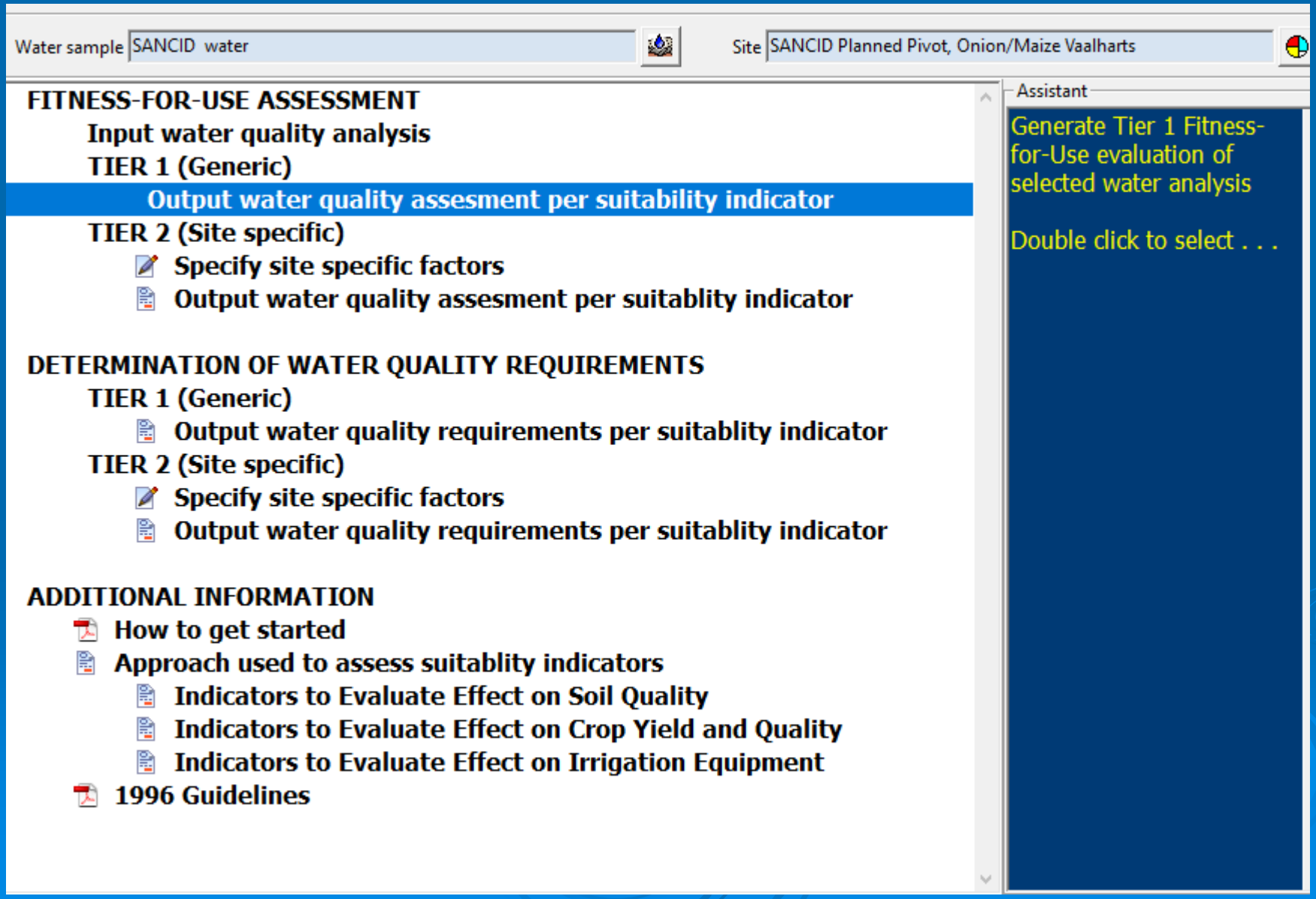

Tier 1 Water & Site Properties

Irrigation Water Fitness-for-Use (Tier 1)

Sample identification:	43: SANCID water
Site description:	41: Generic using conservative assumptions

Water Analysis

Major constituents (mg/L)

Calcium	90.0	Bicarbonate	140.0
Magnesium	35.0	Chloride	140.0
Sodium	75.0	Sulphate	200.0
pH	7.5	Total Dissolved solids (TDS)	680.0
Electrical Conductivity (mS/m)	100.0	Suspended solids	40.0
SAR (mol/L)^0.5	1.7		

Biological Constituents

E. coli (counts/100 mL)	2.0E+03
Chemical Oxygen Demand (mg/L)	200

Nutrients (mg/L)

Total inorganic nitrogen (N)	3.0
Total inorganic phosphorous (P)	1.0
Total inorganic potassium (K)	0.5

Pesticides (µg/L)

Atrazine	20.0

Trace Elements in irrigation water (µg/L) and soil (mg/kg)

	Water	Soil		Water	Soil
Aluminium	1	0	Lead	0	0
Arsenic		0	Lithium	2000	0
Beryllium	30	0	Manganese	300	0
Boron	200	0	Mercury	1	0
Cadmium	2	0	Molybdenum	8	0
Chromium	40	0	Nickel	90	0
Cobalt		0	Selenium	9	0
Copper	100	0	Uranium	5	0
Fluoride	800	0	Vanadium	70	0
Iron		0	Zinc	300	0

Tier 1 Output Page 2 Soil Quality (i)

Tier 1: Fitness-for-Use
Soil Quality

	Fitness-for-use	Root zone salinity (mS/m)	Predicted equilibrium root zone salinity (mS/m)
Root zone salinity	Ideal	0 - 200	188
	Acceptable	200 - 400	
	Tolerable	400 - 800	
	Unacceptable	> 800	

	Fitness-for-use	Degree of reduced Permeability	Qualitative indication of the impact on soil permeability as manifested by reduced:	
			Surface Infiltrability	Soil Hydraulic Conductivity
Soil Permeability	Ideal	None		None
	Acceptable	Slight	Slight	
	Tolerable	Moderate		
	Unacceptable	Severe		

	Fitness-for-use	COD Load (kg/ha per month)	Chemical Oxygen Demand (COD) Load (kg/ha per month)
Oxidisable Carbon Loading	Ideal	0 - 400	167
	Acceptable	400 - 1000	
	Tolerable	1000 - 1600	
	Unacceptable	>1600	

Tier 1 Output Page 2
Soil Quality (ii)

	Fitness-for-use		Number of years of 1000 mm irrigation before Trace Elements reach accumulation threshold in topsoil			
	Ideal		> 200 years to reach soil accumulation threshold			
	Acceptable		150 to 200 years to reach soil accumulation threshold			
	Tolerable		100 to 150 years to reach soil accumulation threshold			
	Unacceptable		< 100 years to reach soil accumulation threshold			
	Trace Element	Soil Accumulation Threshold (mg/kg)	No of years to reach Soil Accumulation Threshold	Trace Element	Soil Accumulation Threshold (mg/kg)	No of years to reach Soil Accumulation Threshold
Trace Element Accumulation	Al	2500	> 1000	Li	1250	125
	As	50	No data	Mn	100	67
	Be	50	333	Hg	1	200
	Cd	5	500	Mo	5	125
	Cr	50	250	Ni	100	222
	Co	25	No data	Se	10	222
	Cu	100	200	U	5	200
	F	1000	250	Va	50	143
	Fe	2500	No data	Zn	500	333
	Pb	100	Infinite			

Tier 1 Output Page 3
Crop Yield / Quality (i)

Tier 1: Fitness-for-Use

Yield and Quality of a Generic Sensitive Crop with 1000 mm irrigation p.a.

	Fitness-for-use	Relative crop yield (%)	Predicted relative crop yield (%) as affected by:			
			Salinity (EC)	Boron (B)	Chloride (Cl)	Sodium (Na)
Root Zone Effects	Ideal	90 - 100		97	100	100
	Acceptable	80 - 90				
	Tolerable	70 - 80				
	Unacceptable	<70	65			

	Fitness-for-use	Degree of leaf scorching	Degree of leaf scorching under sprinkler irrigation caused by:	
			Chloride (Cl)	Sodium (Na)
Leaf scorching when wetted	Ideal	None		
	Acceptable	Slight		Slight
	Tolerable	Moderate	Moderate	
	Unacceptable	Severe		

Tier 1 Output Page 3
Crop Yield / Quality (ii)

Contribution to NPK removal by generic sensitive crop	Fitness-for-use	Contribution to estimated N P K Removal by crop	% of estimated N P K removal at harvest and amount that is applied through irrigation (High nutrient concentrations may impact development of sensitive crops)					
			Nitrogen (N)		Phosphorous (P)		Potassium (K)	
			Removal (%)	Applied (kg/ha)	Removal (%)	Applied (kg/ha)	Removal (%)	Applied (kg/ha)
	Ideal	0 - 10%						
	Acceptable	10 - 30%						
	Tolerable	30 - 50%						
	Unacceptable	>50%	60	30	100	10	50	5

Microbial Contamination	Fitness-for-use	Excess infections per 1000 persons p.a.	Predicted excess infections per 1000 people p.a.
	Ideal	<1	
	Acceptable	1 - 3	
	Tolerable	3 - 10	5.8
	Unacceptable	>10	

Qualitative Atrazine Damage	Fitness-for-use	Atrazine load (g/ha)	Estimated Atrazine load (g/ha)
	Ideal	<50	
	Acceptable	50 - 75	
	Tolerable	75 - 100	
	Unacceptable	>100	200

Tier 1 Output Page 4
Irrigation Equipment

Tier 1: Fitness-for-Use
Irrigation Equipment

Corrosion or Scaling of Irrigation Equipment

Fitness-for-use	Fitness for Use Category determined by the corrosion or scaling potential indicated by the Langelier Index			
	Corrosion (Langelier Index)		Scaling (Langelier Index)	
Ideal	-0.5 to 0	-0.06	0 to +0.5	Not Scaling
Acceptable	-0.5 to -1.0		+0.5 to +1.0	
Tolerable	-1.0 to -2.0		+1.0 to +2.0	
Unacceptable	<-2.0		>+2.0	

Clogging of Drippers

Fitness-for-use	Fitness for Use Category determined by the potential of a constituent to cause clogging of drippers									
	Suspended Solids (mg/L)		pH		Manganese (Mn) (mg/L)		Total Iron (Fe) (mg/L)		*E.coli* (10^6 per 100 mL)	
Ideal	<50	40	<7.0		<0.1		<0.2	No data	<1	0.002
Acceptable	50 - 75		7.0 - 7.5		0.1 - 0.5	0.3	0.2 - 0.5		1 - 2	
Tolerable	75 - 100		7.5 - 8.0	7.5	0.5 - 1.5		0.5 - 1.5		2 - 5	
Unacceptable	>100		>8.0		>1.5		>1.5		>5	

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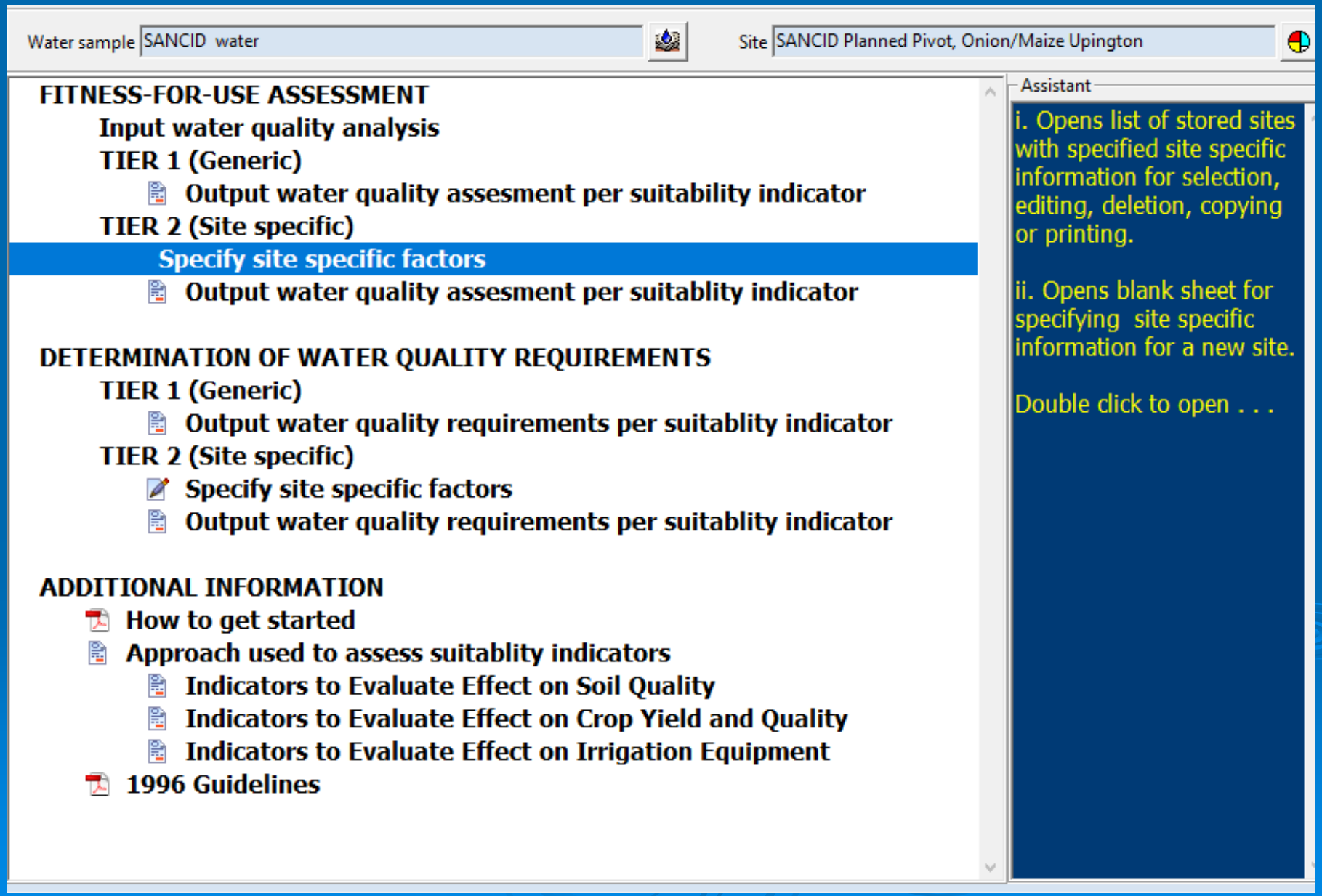
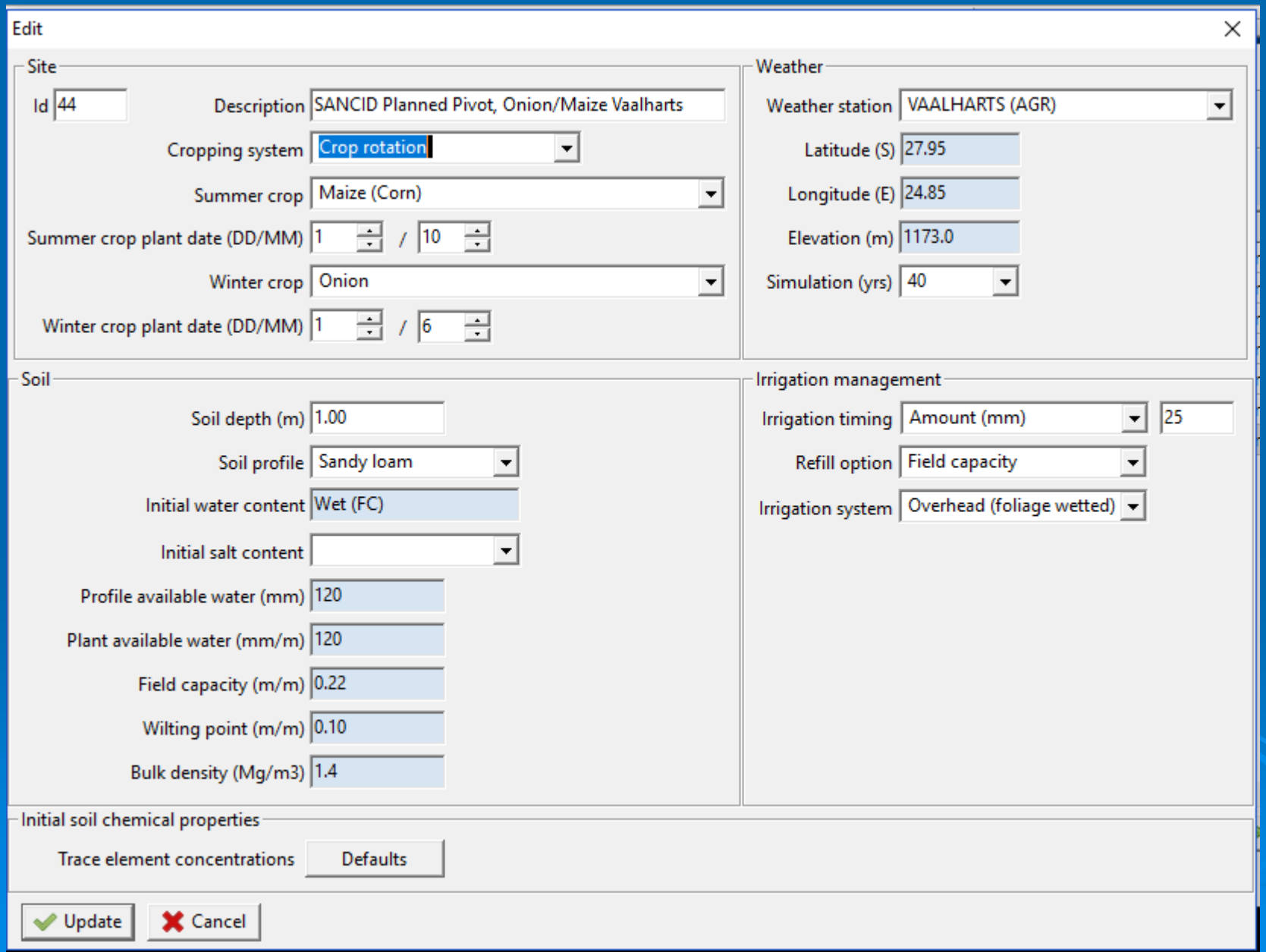
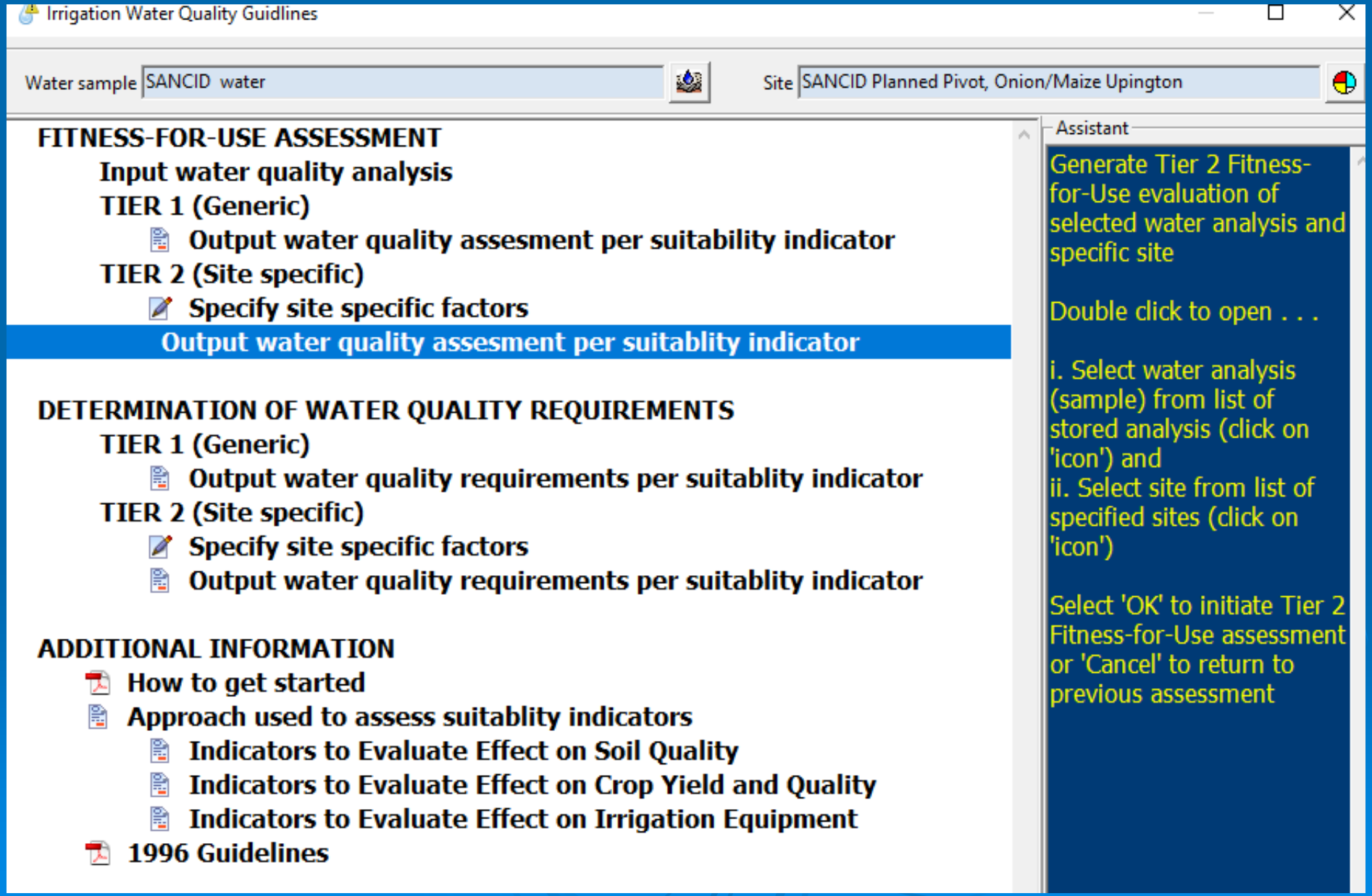


Input / Edit Site Specific Factors



Navigation Screen



Water & Site Properties (a) Tier 2

Irrigation Water Fitness-for-Use (Tier 2)

Sample identification:	43: SANCID water
Site description:	44: SANCID Planned Pivot, Onion/Maize Vaalharts

Water Analysis

Major constituents (mg/L)

Calcium	90.0	Bicarbonate	140.0
Magnesium	35.0	Chloride	140.0
Sodium	75.0	Sulphate	200.0
pH	7.5	Total Dissolved solids (TDS)	680.0
Electrical Conductivity (mS/m)	100.0	Suspended solids	40.0
SAR (mol/L)^0.5	1.7		

Biological Constituents

E. coli (counts/100 mL)	2.0E+03
Chemical Oxygen Demand (mg/L)	200

Nutrients (mg/L)

Total inorganic nitrogen (N)	3.0
Total inorganic phosphorous (P)	1.0
Total inorganic potassium (K)	0.5

Pesticides (µg/L)

Atrazine	20.0

Trace Elements in irrigation water (µg/L) and soil (mg/kg)

	Water	Soil		Water	Soil
Aluminium	1	0	Lead	0	0
Arsenic		0	Lithium	2000	0
Beryllium	30	0	Manganese	300	0
Boron	200	0	Mercury	1	0
Cadmium	2	0	Molybdenum	8	0
Chromium	40	0	Nickel	90	0
Cobalt		0	Selenium	9	0
Copper	100	0	Uranium	5	0
Fluoride	800	0	Vanadium	70	0
Iron		0	Zinc	300	0

Water & Site Properties (b) Tier 2

Site Specific Characteristics

Crop		Soil	
Summer crop	Maize (Corn)	Soil texture	Sandy loam
Plant date (DD/MM)	1/10	Soil depth (m)	1.0
Winter crop	Onion	Initial water content	Wet (FC)
Plant date (DD/MM)	1/6	Profile available water (mm)	120
Irrigation management		Plant available water (mm/m)	120
Irrigation system	Pivot	Field capacity (m/m)	0.22
Irrigation timing	Amount (mm) 25	Wilting point (m/m)	0.10
Refill option	Field capacity	Bulk density (Mg/m3)	1.40
Weather station	VAALHARTS (AGR) (40 years)		

Water Balance

Water balance components	Maize (Corn)	Onion
Mean irrigation application (mm p.a.)	738	157
Mean rainfall (mm p.a.)	404	31
Mean evaporation (mm p.a.)	351	94
Mean transpiration (mm p.a.)	707	89
Mean evapotranspiration (mm p.a.)	1058	183
Mean drainage (mm p.a.)	86	4
Effective leaching fraction (%)	7.5	2.0

Version: 8 Nov 2018

Tier 2 Soil Quality (a)

Tier 2: Fitness-for-Use

Soil Quality of a Sandy loam soil with 901 mm irrigation p.a.

	Fitness-for-use	Root zone salinity (mS/m)	% of time root zone salinity is predicted to fall within a particular Fitness-for-use category
Root zone salinity	Ideal	0 - 200	100
	Acceptable	200 - 400	
	Tolerable	400 - 800	
	Unacceptable	> 800	

	Fitness-for-use	Degree of reduced Permeability	% of time soil permeability is predicted to fall within a particular Fitness-for-use category	
			Surface Infiltrability	Soil Hydraulic Conductivity
Soil Permeability	Ideal	None	1	72
	Acceptable	Slight	99	7
	Tolerable	Moderate		5
	Unacceptable	Severe		16

	Fitness-for-use	COD Load (kg/ha per month)	% of time Chemical Oxygen Demand (COD) Load is predicted to fall within a particular Fitness-for-use category
Oxidisable Carbon Loading	Ideal	0 - 400	94
	Acceptable	400 - 1000	6
	Tolerable	1000 - 1600	
	Unacceptable	>1600	

Tier 2 Soil Quality (b)

	Fitness-for-use		Number of years of 901 mm irrigation before Trace Elements reach accumulation threshold in topsoil			
	Ideal		> 200 years to reach soil accumulation threshold			
	Acceptable		150 to 200 years to reach soil accumulation threshold			
	Tolerable		100 to 150 years to reach soil accumulation threshold			
	Unacceptable		< 100 years to reach soil accumulation threshold			
	Trace Element	Soil Accumulation Threshold (mg/kg)	No of years to reach Soil Accumulation Threshold	Trace Element	Soil Accumulation Threshold (mg/kg)	No of years to reach Soil Accumulation Threshold
Trace Element Accumulation	Al	2500	> 1000	Li	1250	139
	As	50	No data	Mn	100	74
	Be	50	370	Hg	1	222
	Cd	5	555	Mo	5	139
	Cr	50	277	Ni	100	247
	Co	25	No data	Se	10	247
	Cu	100	222	U	5	222
	F	1000	277	Va	50	159
	Fe	2500	No data	Zn	500	370
	Pb	100	Infinite			

Tier 2 Crop yield & Quality (a) Maize

Tier 2: Fitness-for-Use

Yield and Quality of a Maize (Corn) crop with 738 mm irrigation per season

	Fitness-for-use	Relative crop yield (%)	% of time yield is within relative crop yield category, as affected by:			
			Salinity (EC)	Boron (B)	Chloride (Cl)	Sodium (Na)
Root Zone Effects	Ideal	90 - 100	100	95	100	100
	Acceptable	80 - 90				
	Tolerable	70 - 80		5		
	Unacceptable	<70				

	Fitness-for-use	Degree of leaf scorching	Degree of leaf scorching under sprinkler irrigation caused by:	
			Chloride (Cl)	Sodium (Na)
Leaf scorching when wetted	Ideal	None	None	None
	Acceptable	Slight		
	Tolerable	Moderate		
	Unacceptable	Severe		

Tier 2 Crop Yield & Quality (b) Maize

Contribution to NPK removal	Fitness-for-use	Contribution to estimated N P K Removal by crop	Mean applied N P K at harvest and % of time N P K removal at harvest is within fitness-for-use categories (High nutrient concentrations may impact development of sensitive crops)					
			Nitrogen (N)		Phosphorous (P)		Potassium (K)	
			Time (%)	Applied (kg/ha)	Time (%)	Applied (kg/ha)	Time (%)	Applied (kg/ha)
	Ideal	0 - 10%	100	23	10	5	100	4
	Acceptable	10 - 30%			90	8		
	Tolerable	30 - 50%						
	Unacceptable	>50%						

Microbial Contamination	Fitness-for-use	Excess infections per 1000 persons p.a.	Predicted excess infections per 1000 people p.a.
	Ideal	<1	Maize (Corn) not consumed raw
	Acceptable	1 - 3	
	Tolerable	3 - 10	
	Unacceptable	>10	

Qualitative Atrazine Damage	Fitness-for-use	Atrazine load (Maize, SaLm) (g/ha)	% of time Atrazine load is predicted to fall within particular fitness-for-use category
	Ideal	<900	100
	Acceptable	900 - 1300	
	Tolerable	1300 - 1800	
	Unacceptable	>1800	

Tier 2 Crop Yield & Quality (a) Onion

Tier 2: Fitness-for-Use

Yield and Quality of a Onion crop with 157 mm irrigation per season

	Fitness-for-use	Relative crop yield (%)	% of time yield is within relative crop yield category, as affected by:			
			Salinity (EC)	Boron (B)	Chloride (Cl)	Sodium (Na)
Root Zone Effects	Ideal	90 - 100	100	78	100	100
	Acceptable	80 - 90		18		
	Tolerable	70 - 80		2		
	Unacceptable	<70		2		

	Fitness-for-use	Degree of leaf scorching	Degree of leaf scorching under sprinkler irrigation caused by:	
			Chloride (Cl)	Sodium (Na)
Leaf scorching when wetted	Ideal	None	No scorching parameter	No scorching parameter
	Acceptable	Slight		
	Tolerable	Moderate		
	Unacceptable	Severe		

Tier 2 Crop Yield & Quality (b) Onion

Contribution to NPK removal	Fitness-for-use	Contribution to estimated N P K Removal by crop	Mean applied N P K at harvest and % of time N P K removal at harvest is within fitness-for-use categories (High nutrient concentrations may impact development of sensitive crops)					
			Nitrogen (N)		Phosphorous (P)		Potassium (K)	
			Time (%)	Applied (kg/ha)	Time (%)	Applied (kg/ha)	Time (%)	Applied (kg/ha)
	Ideal	0 - 10%	100	5	100	2	No parameter	
	Acceptable	10 - 30%						
	Tolerable	30 - 50%						
	Unacceptable	>50%						

Microbial Contamination	Fitness-for-use	Excess infections per 1000 persons p.a.	Predicted excess infections per 1000 people p.a.
	Ideal	<1	
	Acceptable	1 - 3	1.3
	Tolerable	3 - 10	
	Unacceptable	>10	

Qualitative Atrazine Damage	Fitness-for-use	Atrazine load (Onion, SaLm) (g/ha)	% of time Atrazine load is predicted to fall within particular fitness-for-use category
	Ideal	<90	100
	Acceptable	90 - 130	
	Tolerable	130 - 180	
	Unacceptable	>180	

Tier 2 Irrigation Equipment

Tier 2: Fitness-for-Use
Irrigation Equipment

Corrosion or Scaling of Irrigation Equipment

Fitness-for-use	Fitness for Use Category determined by the corrosion or scaling potential indicated by the Langelier Index			
	Corrosion (Langelier Index)		Scaling (Langelier Index)	
Ideal	0 to -0.5	-0.06	0 to +0.5	Not Scaling
Acceptable	-0.5 to -1.0		+0.5 to +1.0	
Tolerable	-1.0 to -2.0		+1.0 to +2.0	
Unacceptable	<-2.0		>+2.0	

Clogging of Drippers

Fitness-for-use	Fitness for Use Category determined by the potential of an irrigation water constituent to cause clogging of drippers									
	Suspended Solids (mg/L)		pH		Manganese (Mn) (mg/L)		Total Iron (Fe) (mg/L)		*E.coli* (10^6 per 100 mL)	
Ideal	<50	40	<7.0		<0.1		<0.2	No data	<1	0.002
Acceptable	50 - 75		7.0 - 7.5		0.1 - 0.5	0.3	0.2 - 0.5		1 - 2	
Tolerable	75 - 100		7.5 - 8.0	7.5	0.5 - 1.5		0.5 - 1.5		2 - 5	
Unacceptable	>100		>8.0		>1.5		>1.5		>5	

The Way Forward

- Developed a DSS that introduce site specificity in the evaluation of the Fitness-for-Use of irrigation WQ
- The DSS is available for download and testing by the user community. We look forward to your feed-back.
- The WRC approved a follow-on project that will allow us to enhance the features of the DSS and attend to potential “bugs”
- Invite everyone to contact John Annandale or myself if you would like to be involved in this process.

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Thank you for your attention

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