



# Using Alternatives Assessment strategies to drive the greening of TRI releases

Alternatives Assessments for Improved Environmental Outcomes

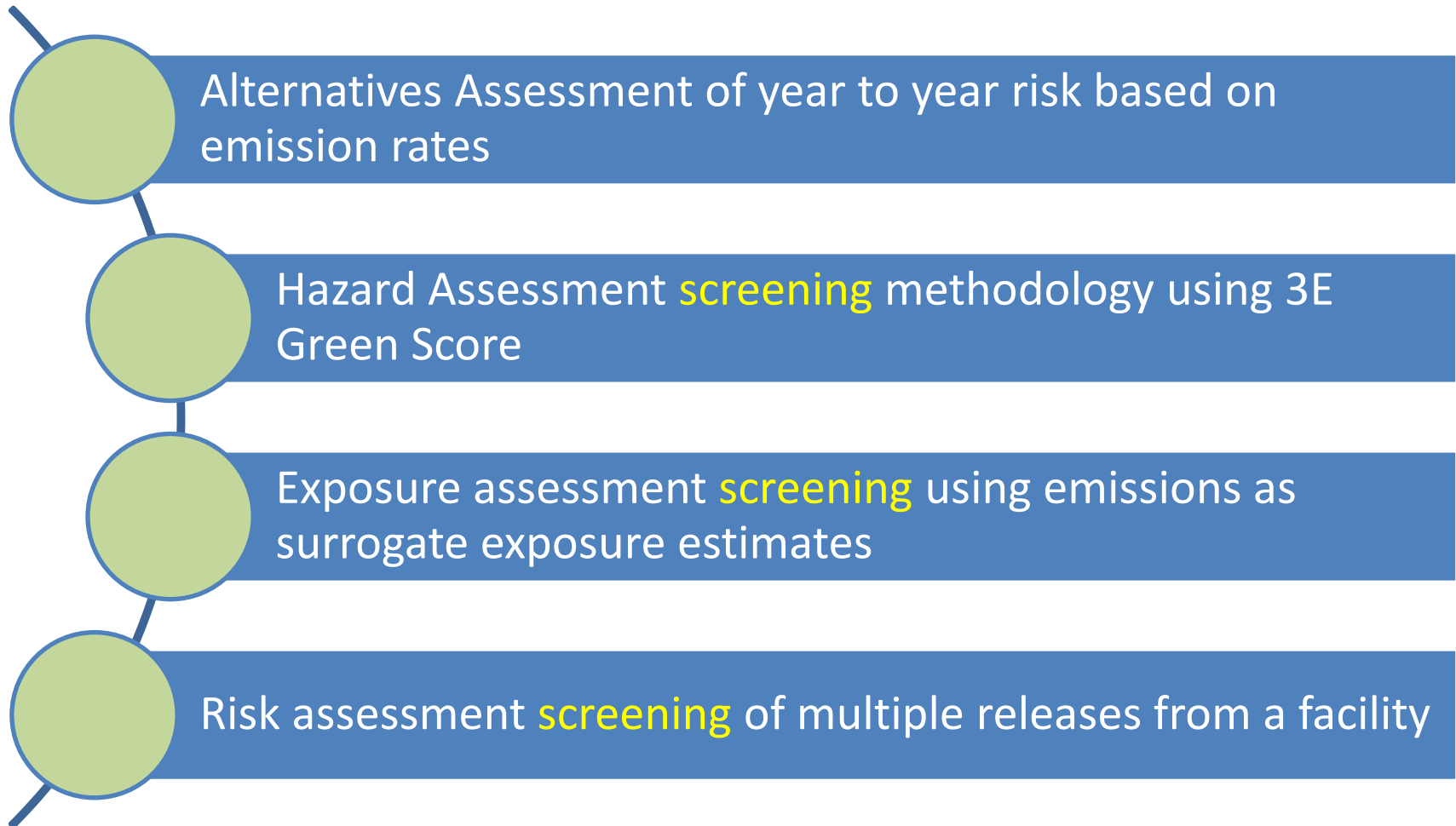
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3E is a Verisk Analytics business.



**Hazard Assessment** – the inherent hazard of a chemical via specific or all routes of exposure without consideration of exposure

**Exposure Assessment** – the likely amount of chemical exposure to occur from a specific usage scenario for a chemical/product

**Risk Assessment** – the probability of an effect resulting from a particular chemical exposure scenario – for a single chemical and scenario, the product of exposure and hazard

List data

Classification data

Scientific data

Probabilistic data

## Scores

- Scientific data
- Continuous data analytics

## Pre-regulatory input

- Anticipates future regulatory restrictions

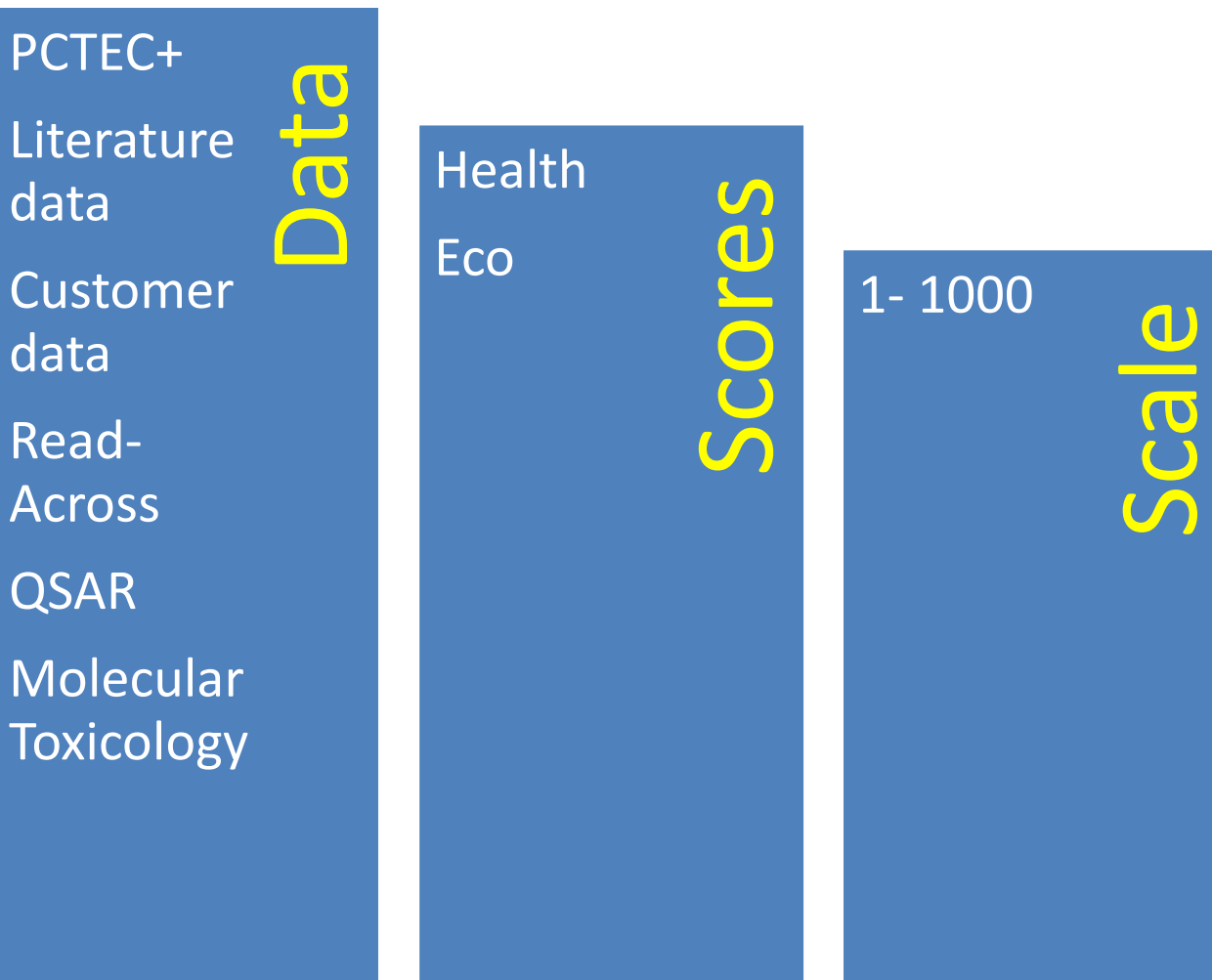
## Drill-Down

- Multiple tiers

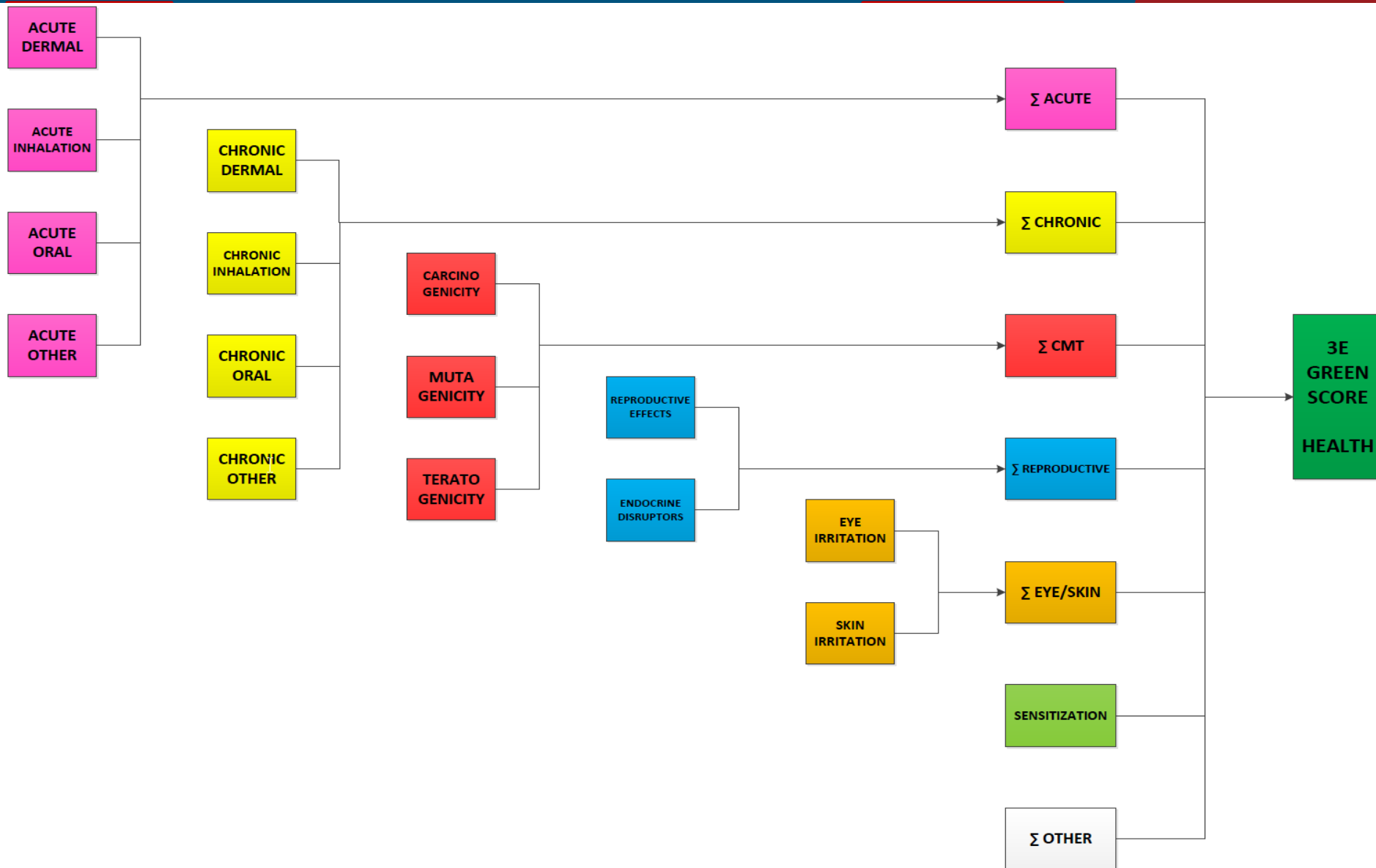
## Mixtures

- Down to 1 ppm level

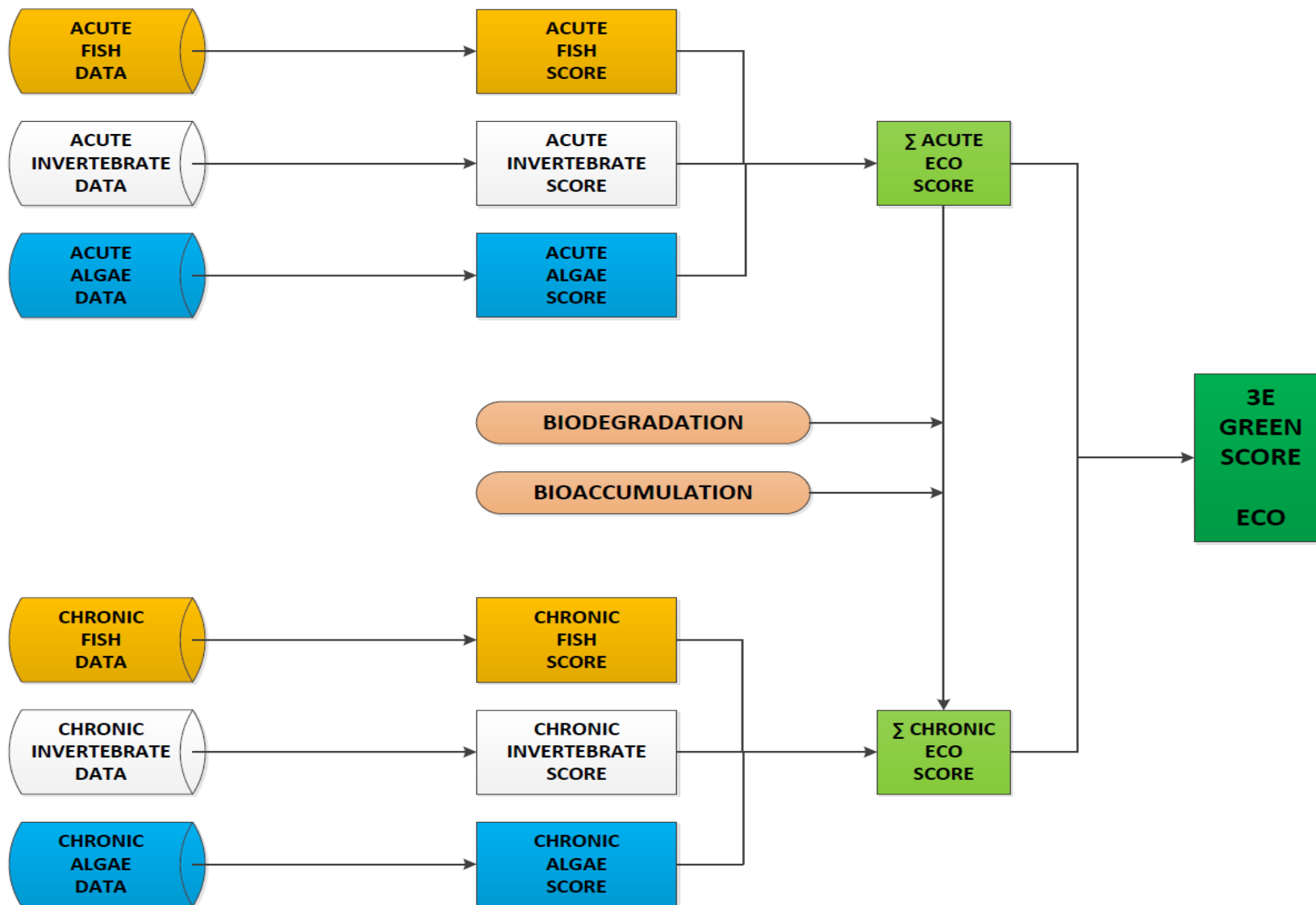
# Data: 3E Green Score



# 3E Green Score: HEALTH



# 3E Green Score: ECO





**Hazard Assessment** – the inherent hazard of a chemical via specific or all routes of exposure without consideration of exposure

**Exposure Assessment** – the likely amount of chemical exposure to occur from a specific usage scenario for a chemical/product

**Risk Assessment** – the probability of an effect resulting from a particular chemical exposure scenario – for a single chemical and scenario, the product of exposure and hazard

# Alternative Assessments - 1



	Year 1		Health Effect	Year 2	
	Risk	Emissions		Emissions	Risk
Chemical A	139	30000	216	35000	162
Chemical B	253	40000	158	20000	127
Chemical C	93	40000	432	60000	139
	<b>485</b>	<b>110000</b>		<b>115000</b>	<b>428</b>
Chemical A	46	10000	216	10000	46
Chemical B	127	20000	158	20000	127
Chemical C	208	90000	432	75000	174
	<b>381</b>	<b>120000</b>		<b>105000</b>	<b>346</b>
Chemical A	46	10000	216	10000	46
Chemical B	63	10000	158	10000	63
Chemical C	208	90000	432	80000	185
	<b>318</b>	<b>110000</b>		<b>100000</b>	<b>295</b>

# Alternative Assessments - 2



	Year 1		Health Effect	Year 2	
	Risk	Emissions		Emissions	Risk
Chemical A	139	30000	216	35000	162
Chemical B	253	40000	158	20000	127
Chemical D	47	40000	850	60000	71
	<b>439</b>	<b>110000</b>		<b>115000</b>	<b>359</b>
Chemical A	46	10000	216	10000	46
Chemical B	127	20000	158	20000	127
Chemical D	106	90000	850	75000	88
	<b>279</b>	<b>120000</b>		<b>105000</b>	<b>261</b>
Chemical A	46	10000	216	10000	46
Chemical B	63	10000	158	10000	63
Chemical D	106	90000	850	80000	94
	<b>215</b>	<b>110000</b>		<b>100000</b>	<b>204</b>

# Alternative Assessments - 3



	Year 1		Health	Year 2	
	Risk	Emissions	Score	Emissions	Risk
Chemical A	139	30000	216	35000	162
Chemical B	253	40000	158	20000	127
Chemical C	93	40000	432	60000	139
	<b>485</b>	<b>110000</b>		<b>115000</b>	<b>428</b>
Chemical A	46	10000	216	10000	46
Chemical B	127	20000	158	20000	127
Chemical D	0	0	850	0	0
	<b>173</b>	<b>30000</b>		<b>30000</b>	<b>173</b>
Chemical A	46	10000	216	10000	46
Chemical B	63	10000	158	10000	63
Chemical D	0	0	850	0	0
	<b>110</b>	<b>20000</b>		<b>20000</b>	<b>110</b>

# Emission Data for Facility X



EMISSION TREND	CHEMICAL	CAS	TOTAL RELEASES 2015 (Kg)	TOTAL RELEASES 2014 (Kg)	INCREASE/ DECREASE (Kg)	%
INCREASED IN 2015	N-BUTYL ALCOHOL	71-36-3	2764.2	2127.8	636.4	29.9
	BENZENE	71-43-2	58.1	13.6	44.5	326.7
	ETHYLENE	74-85-1	207.7	49.0	158.8	324.1
	TRICHLOROETHYLENE	79-01-6	163.7	11.8	152.0	1288.5
	CYCLOHEXANE	110-82-7	20.8	12.7	8.0	63.1
	CHLORINE	7782-50-5	1043.8	514.8	529.0	102.8
DECREASED IN 2015	TERT-BUTYL ALCOHOL	75-65-0	8001.4	10704.8	-2703.4	-25.3
	1,3-BUTADIENE	106-99-0	10.8	98.0	-87.2	-89.0
	PROPYLENE	115-07-1	836.9	2540.6	-1703.7	-67.1
	ARSENIC	7440-38-2	1.6	16.9	-15.3	-90.3
	HYDROGEN FLUORIDE	7664-39-3	174.3	2483.9	-2309.6	-93.0
	AMMONIA	7664-41-7	109.3	727.7	-618.4	-85.0
	NAPHTHALENE	91-20-3	8.8	7.9	0.9	11.9
	ETHYLBENZENE	100-41-4	16.7	17.1	-0.4	-2.2
	TOLUENE	108-88-3	74.8	75.1	-0.4	-0.5
	PHENOL	108-95-2	21.4	22.3	-0.9	-3.9
			<b>13514.3</b>	<b>19423.9</b>		<b>-30.4</b>

# 3E Green Scores Health



		ETHYLBENZENE	1,3-BUTADIENE	TOLUENE	PHENOL	CYCLOHEXANE	PROPYLENE	N-BUTYL ALCOHOL	BENZENE	ARSENIC	ETHYLENE	TERT-BUTYL ALCOHOL	HYDROGEN FLUORIDE	AMMONIA	CHLORINE	TRICHLOROETHYLENE	NAPHTH
	CAS#	100-41-4	106-99-0	108-88-3	108-95-2	110-82-7	115-07-1	71-36-3	71-43-2	7440-38-2	74-85-1	75-65-0	7664-39-3	7664-41-7	7782-50-5	79-01-6	91-20-3
ACUTE ORAL	SCORE	769	762	744	547	683		636	629	493	668	769		570	536	737	606
ACUTE DERMAL	SCORE	888		750	506	651		709	804						826	151	
ACUTE INHALATION	SCORE	606	334	373	148	639	699	676	698		699		334	536	251	681	208
ACUTE OVERALL	SCORE	745	504	593	345	657	699	673	707	493	683	769	334	553	481	423	355
CHRONIC ORAL	SCORE	576		760	661			620	201	17			496	681	429	541	546
CHRONIC DERMAL	SCORE				529												620
CHRONIC INHALATION	SCORE	506	242	536	396	684	930	1	299		646		58		1	536	71
CHRONIC OVERALL	SCORE	540	242	638	517	684	930	25	245	17	646		170	681	21	538	289
CARCINOGENICITY	SCORE	100	1	350	350		350		1	100	850	350	350	850	850	1	150
MUTAGENICITY	SCORE	100	50	850	150	850	100	100	50	100	850		100	850	100	150	100
TERATOGENICITY	SCORE	350	350	100	100	350	350	350	350	350	350		350	350	350	350	
CMT OVERALL	SCORE	152	26	310	174	545	231	187	26	152	632	350	231	632	310	37	122
REPRODUCTIVE EFFECTS	SCORE	300	100	150	300	300	300	300	300	300	300		100	300	100	100	100
ENDOCRINE DISRUPTOR	SCORE	850		550		850		850								550	
REPRO OVERALL	SCORE	505	100	287	300	505	300	300	505	300	300		100	300	100	235	100
EYE IRRITATION	SCORE	250	600	250		900		50	250			250	600	250	250	250	350
SKIN IRRITATION	SCORE	200	600	350	100	300		300	300				50	100	300	300	350
EYE/SKIN OVERALL	SCORE	224	600	296	100	520		122	274			250	173	158	274	274	350
SENSITIZATION	SCORE	750		750	750	750		750	550		550				750	200	750
3E GREEN HEALTH	SCORE	416	180	442	298	603	460	210	264	140	540	407	187	408	200	219	263

# 3E Green Scores ECO



		ETHYLBENZENE	1,3-BUTADIENE	TOLUENE	PHENOL	CYCLOHEXANE	PROPYLENE	N-BUTYL ALCOHOL	BENZENE	ARSENIC	ETHYLENE	TERT-BUTYL ALCOHOL	HYDROGEN FLUORIDE	AMMONIA	CHLORINE	TRICHLOROETHYLENE	NAPHTHAL
	CAS#	100-41-4	106-99-0	108-88-3	108-95-2	110-82-7	115-07-1	71-36-3	71-43-2	7440-38-2	74-85-1	75-65-0	7664-39-3	7664-41-7	7782-50-5	79-01-6	91-20-3
ACUTE FISH	SCORE	304	518	346	340	331	543	600	338	138	620	786	542	1	1	441	190
ACUTE INVERTEBRATES	SCORE	138	469	1	185	191	118	854	1	118	559	651	404	428	1	429	267
ACUTE ALGAE	SCORE	311	405	518	539	267	417	670			496	798	527	886		512	120
ACUTE OVERALL	SCORE	235	462	56	324	257	299	700	18	128	556	742	487	72	1	459	183
CHRONIC FISH	SCORE	304	722	629	377	331	745	331	731	138	619	1000	720	136	29	752	408
CHRONIC INVERTEBRATES	SCORE	600	682	574	400	191	698	781	446	118	560	1000	714	380	1	429	1
CHRONIC ALGAE	SCORE	311	405	518	539	267	417	670			496	798	527	886		512	120
CHRONIC OVERALL	SCORE	384	584	572	433	257	601	557	571	128	556	928	647	358	5	549	37
ECO OVERALL	SCORE	301	519	180	374	257	424	625	102	128	556	830	561	161	2	502	82

# 3E Green Scores Overview 2014



COMPONENT	CAS	EMISSIONS 2014 (kg)	3E Green Score	
			ECO	HEALTH
ETHYLBENZENE	100-41-4	17.1	301	416
1,3-BUTADIENE	106-99-0	98.0	519	180
TOLUENE	108-88-3	75.1	180	442
PHENOL	108-95-2	22.3	374	298
CYCLOHEXANE	110-82-7	12.7	257	603
PROPYLENE	115-07-1	2540.6	424	460
N-BUTYL ALCOHOL	71-36-3	2127.8	625	210
BENZENE	71-43-2	13.6	102	264
ARSENIC	7440-38-2	16.9	128	140
ETHYLENE	74-85-1	49.0	556	540
TERT-BUTYL ALCOHOL	75-65-0	10704.8	830	407
HYDROGEN FLUORIDE	7664-39-3	2483.9	561	187
AMMONIA	7664-41-7	727.7	161	408
CHLORINE	7782-50-5	514.8	2	200
TRICHLOROETHYLENE	79-01-6	11.8	502	219
NAPHTHALENE	91-20-3	7.9	82	263
Sum of all constituents assessed		19423.9		
<b>Emission weighted geometric mean</b>			<b>555</b>	<b>340</b>



# 3E Green Scores Overview 2015



COMPONENT	CAS	EMISSIONS 2015 (kg)	3E Green Score	
			ECO	HEALTH
ETHYLBENZENE	100-41-4	16.7	301	416
1,3-BUTADIENE	106-99-0	10.8	519	180
TOLUENE	108-88-3	74.8	180	442
PHENOL	108-95-2	21.4	374	298
CYCLOHEXANE	110-82-7	20.8	257	603
PROPYLENE	115-07-1	836.9	424	460
N-BUTYL ALCOHOL	71-36-3	2764.2	625	210
BENZENE	71-43-2	58.1	102	264
ARSENIC	7440-38-2	1.6	128	140
ETHYLENE	74-85-1	207.7	556	540
TERT-BUTYL ALCOHOL	75-65-0	8001.4	830	407
HYDROGEN FLUORIDE	7664-39-3	174.3	561	187
AMMONIA	7664-41-7	109.3	161	408
CHLORINE	7782-50-5	1043.8	2	200
TRICHLOROETHYLENE	79-01-6	163.7	502	219
NAPHTHALENE	91-20-3	8.8	82	263
Sum of all constituents assessed		13514.3		
<b>Emission weighted geometric mean</b>			<b>452</b>	<b>334</b>

# Emission Health Risk 2014



CHEMICAL	CAS	3E Green Score	Emissions 2014 in kg	Health Risk 2014
N-BUTYL ALCOHOL	71-36-3	210	2128	10
BENZENE	71-43-2	264	14	0
ETHYLENE	74-85-1	540	49	0
TERT-BUTYL ALCOHOL	75-65-0	407	10705	26
TRICHLOROETHYLENE	79-01-6	219	12	0
NAPHTHALENE	91-20-3	263	8	0
ETHYLBENZENE	100-41-4	416	17	0
1,3-BUTADIENE	106-99-0	180	98	1
TOLUENE	108-88-3	442	75	0
PHENOL	108-95-2	298	22	0
CYCLOHEXANE	110-82-7	603	13	0
PROPYLENE	115-07-1	460	2541	6
ARSENIC	7440-38-2	140	17	0
HYDROGEN FLUORIDE	7664-39-3	187	2484	13
AMMONIA	7664-41-7	408	728	2
CHLORINE	7782-50-5	200	515	3
<b>Total</b>			<b>19424</b>	<b>61</b>

# Emission Health Risk 2014 vs 2015



CAS	CHEMICAL	Health Risk 2015	Emissions 2015 (kg)	3E Green Score	Emissions 2014 (kg)	Health Risk 2014
71-36-3	N-BUTYL ALCOHOL	13	2764	210	2128	10
71-43-2	BENZENE	0	58	264	14	0
74-85-1	ETHYLENE	0	208	540	49	0
75-65-0	TERT-BUTYL ALCOHOL	20	8001	407	10705	26
79-01-6	TRICHLOROETHYLENE	1	164	219	12	0
91-20-3	NAPHTHALENE	0	9	263	8	0
100-41-4	ETHYLBENZENE	0	17	416	17	0
106-99-0	1,3-BUTADIENE	0	11	180	98	1
108-88-3	TOLUENE	0	75	442	75	0
108-95-2	PHENOL	0	21	298	22	0
110-82-7	CYCLOHEXANE	0	21	603	13	0
115-07-1	PROPYLENE	2	837	460	2541	6
7440-38-2	ARSENIC	0	2	140	17	0
7664-39-3	HYDROGEN FLUORIDE	1	174	187	2484	13
7664-41-7	AMMONIA	0	109	408	728	2
7782-50-5	CHLORINE	5	1044	200	515	3
<b>Total</b>		<b>43</b>	<b>13514</b>		<b>19424</b>	<b>61</b>

# Emissions Eco Risk 2014



CAS	CHEMICAL	3E Green Score	Emissions 2014 in kg	ECO Risk 2014
71-36-3	N-BUTYL ALCOHOL	625	2128	3
71-43-2	BENZENE	102	14	0
74-85-1	ETHYLENE	556	49	0
75-65-0	TERT-BUTYL ALCOHOL	830	10705	13
79-01-6	TRICHLOROETHYLENE	502	12	0
91-20-3	NAPHTHALENE	82	8	0
100-41-4	ETHYLBENZENE	301	17	0
106-99-0	1,3-BUTADIENE	519	98	0
108-88-3	TOLUENE	180	75	0
108-95-2	PHENOL	374	22	0
110-82-7	CYCLOHEXANE	257	13	0
115-07-1	PROPYLENE	424	2541	6
7440-38-2	ARSENIC	128	17	0
7664-39-3	HYDROGEN FLUORIDE	561	2484	4
7664-41-7	AMMONIA	161	728	5
7782-50-5	CHLORINE	2	515	222
	<b>Total</b>		<b>19424</b>	<b>254</b>

# Emissions ECO Risk 2014 vs 2015



CAS	CHEMICAL	ECO Risk 2015	Emissions 2015 (kg)	3E Green Score	Emissions 2014 (kg)	ECO Risk 2014
71-36-3	N-BUTYL ALCOHOL	4	2764	625	2128	3
71-43-2	BENZENE	1	58	102	14	0
74-85-1	ETHYLENE	0	208	556	49	0
75-65-0	TERT-BUTYL ALCOHOL	10	8001	830	10705	13
79-01-6	TRICHLOROETHYLENE	0	164	502	12	0
91-20-3	NAPHTHALENE	0	9	82	8	0
100-41-4	ETHYLBENZENE	0	17	301	17	0
106-99-0	1,3-BUTADIENE	0	11	519	98	0
108-88-3	TOLUENE	0	75	180	75	0
108-95-2	PHENOL	0	21	374	22	0
110-82-7	CYCLOHEXANE	0	21	257	13	0
115-07-1	PROPYLENE	2	837	424	2541	6
7440-38-2	ARSENIC	0	2	128	17	0
7664-39-3	HYDROGEN FLUORIDE	0	174	561	2484	4
7664-41-7	AMMONIA	1	109	161	728	5
7782-50-5	CHLORINE	450	1044	2	515	222
<b>TOTAL</b>		<b>469</b>	<b>13514</b>		<b>19424</b>	<b>254</b>

# Overview of Emissions and Effects



	2014	2015	%
Total emissions	19424	13514	-30
Total Health Risk	61	43	-30
Weighted Health Score	340	334	-2
Total ECO risk	254	469	84
Weighted ECO score	555	452	-19

- Alternative assessment methodologies can assist in decision-making
- Overall emissions are not always the best surrogate for risks from emissions
- 3E Green Score allows hazard/risk comparison across multiple chemicals and media
- Screening hazard/exposure/risk provide a wealth of information at a fraction of the effort and cost of their “full-size” cousins

Thank you!

Comments and questions:

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