Section S1a B2-45 Scenario Black Box Interchange Mode. This scenario assumes a 45% struvite recovery based on ammonium and phosphate ion concentrations in the centrate (coming into the electrochemical struvite precipitation reactor). Bolded equations represent modifications made to existing code in GPS-X. Variable names (left of the '&') are defined in the GPS-X documentation and the 'in' or 'out' following the '&' indicate influent or effluent streams to the black box.

```
macro shuffler(in,o)
mapflow(in,o)
mapglobalstoich(o)
maplocalstoich(in,o)
setlocaltemperature(o)
customshuffle(in,o)
compositevars(o)
phestimation(o)
macro end

macro customshuffle(in,out)
!for use with the 'interchange' black box object

!edit this macro to map '&in' varibles
!to corresponding '&out' variables
hmprocedural

q&out=0.999999983*q&in

so&out=(so&in*q&in)/q&out
sh2&out=(sh2&in*q&in)/q&out
sn2&out=(sn2&in*q&in)/q&out
sch4&out=(sch4&in*q&in)/q&out
si&out=(si&in*q&in)/q&out
scol&out=(scol&in*q&in)/q&out
ss&out=(ss&in*q&in)/q&out
sac&out=(sac&in*q&in)/q&out
spro&out=(spro&in*q&in)/q&out
```

smet&out=(smet&in*q&in)/q&out

xi&out=(xi&in*q&in)/q&out

xu&out=(xu&in*q&in)/q&out

xs&out=(xs&in*q&in)/q&out

xbt&out=(xbt&in*q&in)/q&out

snd&out=(snd&in*q&in)/q&out

snoi&out=(snoi&in*q&in)/q&out

snoa&out=(snoa&in*q&in)/q&out

xns&out=(xns&in*q&in)/q&out

xps&out=(xps&in*q&in)/q&out

xpp&out=(xpp&in*q&in)/q&out

xbh&out=(xbh&in*q&in)/q&out

xbf&out=(xbf&in*q&in)/q&out

xbai&out=(xbai&in*q&in)/q&out

xbaa&out=(xbaa&in*q&in)/q&out

xbp&out=(xbp&in*q&in)/q&out

xbpro&out=(xbpro&in*q&in)/q&out

xbacm&out=(xbacm&in*q&in)/q&out

xbh2m&out=(xbh2m&in*q&in)/q&out

xbmet&out=(xbmet&in*q&in)/q&out

xbax&out=(xbax&in*q&in)/q&out

stic&out=(stic&in*q&in)/q&out

sca&out=(sca&in*q&in)/q&out

spot&out=(spot&in*q&in)/q&out

scat&out=(scat&in*q&in)/q&out

sana&out=(sana&in*q&in)/q&out

xii&out=(xii&in*q&in)/q&out

xaloh&out=(xaloh&in*q&in)/q&out

xalpo4&out=(xalpo4&in*q&in)/q&out

xfeoh&out=(xfeoh&in*q&in)/q&out

xfepo4&out=(xfepo4&in*q&in)/q&out

xcaco3&out=(xcaco3&in*q&in)/q&out

xcapo4&out=(xcapo4&in*q&in)/q&out

xmgco3&out=(xmgco3&in*q&in)/q&out

xmghpo4&out=(xmghpo4&in*q&in)/q&out

sza&out=(sza&in*q&in)/q&out

szb&out=(szb&in*q&in)/q&out

xza&out=(xza&in*q&in)/q&out

xzb&out=(xzb&in*q&in)/q&out

!struvite edits

xmgnh4po4&out=(xmgnh4po4&in*q&in + 0.012*(18/14)*snh&in*q&in + 0.45*(95/31)*sp&in*q&in + 0.0000769*smg&in*q&in + 0.000000017*q&in*1000000)/q&out

snh&out=(0.988*snh&in*q&in)/q&out

sp&out=(0.55*sp&in*q&in)/q&out

smg&out=(0.9999231*smg&in*q&in)/q&out

hmend

macro end

Section S1b B2-90 Scenario Black Box Interchange Mode. This scenario assumes a 90% struvite recovery based on ammonium and phosphate ion concentrations in the centrate.

```
macro shuffler(in,o)
mapflow(in,o)
mapglobalstoich(o)
maplocalstoich(in,o)
setlocaltemperature(o)
customshuffle(in,o)
compositevars(o)
phestimation(o)
macro end

macro customshuffle(in,out)
!for use with the 'interchange' black box object

!edit this macro to map '&in' varibles
!to corresponding '&out' variables
hmprocedural

q&out=0.999999966*q&in

so&out=(so&in*q&in)/q&out
sh2&out=(sh2&in*q&in)/q&out
sn2&out=(sn2&in*q&in)/q&out
sch4&out=(sch4&in*q&in)/q&out
si&out=(si&in*q&in)/q&out
scol&out=(scol&in*q&in)/q&out
ss&out=(ss&in*q&in)/q&out
sac&out=(sac&in*q&in)/q&out
spro&out=(spro&in*q&in)/q&out
smet&out=(smet&in*q&in)/q&out
xi&out=(xi&in*q&in)/q&out
xu&out=(xu&in*q&in)/q&out
```

xs&out=(xs&in*q&in)/q&out

xbt&out=(xbt&in*q&in)/q&out

snd&out=(snd&in*q&in)/q&out

snoi&out=(snoi&in*q&in)/q&out

snoa&out=(snoa&in*q&in)/q&out

xns&out=(xns&in*q&in)/q&out

xps&out=(xps&in*q&in)/q&out

xpp&out=(xpp&in*q&in)/q&out

xbh&out=(xbh&in*q&in)/q&out

xbf&out=(xbf&in*q&in)/q&out

xbai&out=(xbai&in*q&in)/q&out

xbaa&out=(xbaa&in*q&in)/q&out

xbp&out=(xbp&in*q&in)/q&out

xbpro&out=(xbpro&in*q&in)/q&out

xbacm&out=(xbacm&in*q&in)/q&out

xbh2m&out=(xbh2m&in*q&in)/q&out

xbmet&out=(xbmet&in*q&in)/q&out

xbax&out=(xbax&in*q&in)/q&out

stic&out=(stic&in*q&in)/q&out

sca&out=(sca&in*q&in)/q&out

spot&out=(spot&in*q&in)/q&out

scat&out=(scat&in*q&in)/q&out

sana&out=(sana&in*q&in)/q&out

xii&out=(xii&in*q&in)/q&out

xaloh&out=(xaloh&in*q&in)/q&out

xalpo4&out=(xalpo4&in*q&in)/q&out

xfeoh&out=(xfeoh&in*q&in)/q&out

xfepo4&out=(xfepo4&in*q&in)/q&out

xcaco3&out=(xcaco3&in*q&in)/q&out

xcapo4&out=(xcapo4&in*q&in)/q&out

xmgco3&out=(xmgco3&in*q&in)/q&out

xmghpo4&out=(xmghpo4&in*q&in)/q&out

sza&out=(sza&in*q&in)/q&out

szb&out=(szb&in*q&in)/q&out

xza&out=(xza&in*q&in)/q&out

xzb&out=(xzb&in*q&in)/q&out

!struvite edits

xmgnh4po4&out=(xmgnh4po4&in*q&in + 0.0234*(18/14)*snh&in*q&in + 0.9*(95/31)*sp&in*q&in + 0.000154*smg&in*q&in + 0.000000034*q&in*1000000)/q&out

snh&out=(0.9766*snh&in*q&in)/q&out

sp&out=(0.1*sp&in*q&in)/q&out

smg&out=(0.999846*smg&in*q&in)/q&out

hmend

macro end

Section S1c A2-45 Scenario Black Box Interchange Mode. This scenario assumes a 45% struvite recovery based on ammonium and phosphate ion concentrations in the centrate.macro shuffler(in,o)

mapflow(in,o)

mapglobalstoich(o)

maplocalstoich(in,o)

setlocaltemperature(o)

customshuffle(in,o)

compositevars(o)

phestimation(o)

macro end

macro customshuffle(in,out)

!for use with the 'interchange' black box object

!edit this macro to map '&in' varibles

!to corresponding '&out' variables

Hmprocedural

q&out=0.999456*q&in

so&out=(so&in*q&in)/q&out

sh2&out=(sh2&in*q&in)/q&out

sn2&out=(sn2&in*q&in)/q&out

sch4&out=(sch4&in*q&in)/q&out

si&out=(si&in*q&in)/q&out

scol&out=(scol&in*q&in)/q&out

ss&out=(ss&in*q&in)/q&out

sac&out=(sac&in*q&in)/q&out

spro&out=(spro&in*q&in)/q&out

smet&out=(smet&in*q&in)/q&out

xi&out=(xi&in*q&in)/q&out

xu&out=(xu&in*q&in)/q&out

xs&out=(xs&in*q&in)/q&out

xbt&out=(xbt&in*q&in)/q&out

snd&out=(snd&in*q&in)/q&out

snoi&out=(snoi&in*q&in)/q&out

snoa&out=(snoa&in*q&in)/q&out

xns&out=(xns&in*q&in)/q&out

xps&out=(xps&in*q&in)/q&out

xpp&out=(xpp&in*q&in)/q&out

xbh&out=(xbh&in*q&in)/q&out

xbf&out=(xbf&in*q&in)/q&out

xbai&out=(xbai&in*q&in)/q&out

xbaa&out=(xbaa&in*q&in)/q&out

xbp&out=(xbp&in*q&in)/q&out

xbpro&out=(xbpro&in*q&in)/q&out

xbacm&out=(xbacm&in*q&in)/q&out

xbh2m&out=(xbh2m&in*q&in)/q&out

xbmet&out=(xbmet&in*q&in)/q&out

xbax&out=(xbax&in*q&in)/q&out

stic&out=(stic&in*q&in)/q&out

sca&out=(sca&in*q&in)/q&out

spot&out=(spot&in*q&in)/q&out

scat&out=(scat&in*q&in)/q&out

sana&out=(sana&in*q&in)/q&out

xii&out=(xii&in*q&in)/q&out

xaloh&out=(xaloh&in*q&in)/q&out

xalpo4&out=(xalpo4&in*q&in)/q&out

xfeoh&out=(xfeoh&in*q&in)/q&out

xfepo4&out=(xfepo4&in*q&in)/q&out

xcaco3&out=(xcaco3&in*q&in)/q&out

xcapo4&out=(xcapo4&in*q&in)/q&out

xmgco3&out=(xmgco3&in*q&in)/q&out

xmghpo4&out=(xmghpo4&in*q&in)/q&out

sza&out=(sza&in*q&in)/q&out

szb&out=(szb&in*q&in)/q&out

xza&out=(xza&in*q&in)/q&out

xzb&out=(xzb&in*q&in)/q&out

!struvite edits

xmgnh4po4&out=(xmgnh4po4&in*q&in + 0.351*(18/14)*snh&in*q&in + 0.45*(95/31)*sp&in*q&in + 0.126*smg&in*q&in + 0.000544*q&in*1000000)/q&out

snh&out=(0.649*snh&in*q&in)/q&out

sp&out=(0.55*sp&in*q&in)/q&out

smg&out=(0.874*smg&in*q&in)/q&out

hmend

macro end

Section S1d A2-90 Scenario Black Box Interchange Mode. This scenario assumes a 90% struvite recovery based on ammonium and phosphate ion concentrations in the centrate.macro shuffler(in,o)

mapflow(in,o)

mapglobalstoich(o)

maplocalstoich(in,o)

setlocaltemperature(o)

customshuffle(in,o)

compositevars(o)

phestimation(o)

macro end

macro customshuffle(in,out)

!for use with the 'interchange' black box object

!edit this macro to map '&in' varibles

!to corresponding '&out' variables

Hmprocedural

q&out=0.998911*q&in

so&out=(so&in*q&in)/q&out

sh2&out=(sh2&in*q&in)/q&out

sn2&out=(sn2&in*q&in)/q&out

sch4&out=(sch4&in*q&in)/q&out

si&out=(si&in*q&in)/q&out

scol&out=(scol&in*q&in)/q&out

ss&out=(ss&in*q&in)/q&out

sac&out=(sac&in*q&in)/q&out

spro&out=(spro&in*q&in)/q&out

smet&out=(smet&in*q&in)/q&out

xi&out=(xi&in*q&in)/q&out

xu&out=(xu&in*q&in)/q&out

xs&out=(xs&in*q&in)/q&out

xbt&out=(xbt&in*q&in)/q&out

snd&out=(snd&in*q&in)/q&out

snoi&out=(snoi&in*q&in)/q&out

snoa&out=(snoa&in*q&in)/q&out

xns&out=(xns&in*q&in)/q&out

xps&out=(xps&in*q&in)/q&out

xpp&out=(xpp&in*q&in)/q&out

xbh&out=(xbh&in*q&in)/q&out

xbf&out=(xbf&in*q&in)/q&out

xbai&out=(xbai&in*q&in)/q&out

xbaa&out=(xbaa&in*q&in)/q&out

xbp&out=(xbp&in*q&in)/q&out

xbpro&out=(xbpro&in*q&in)/q&out

xbacm&out=(xbacm&in*q&in)/q&out

xbh2m&out=(xbh2m&in*q&in)/q&out

xbmet&out=(xbmet&in*q&in)/q&out

xbax&out=(xbax&in*q&in)/q&out

stic&out=(stic&in*q&in)/q&out

sca&out=(sca&in*q&in)/q&out

spot&out=(spot&in*q&in)/q&out

scat&out=(scat&in*q&in)/q&out

sana&out=(sana&in*q&in)/q&out

xii&out=(xii&in*q&in)/q&out

xaloh&out=(xaloh&in*q&in)/q&out

xalpo4&out=(xalpo4&in*q&in)/q&out

xfeoh&out=(xfeoh&in*q&in)/q&out

xfepo4&out=(xfepo4&in*q&in)/q&out

xcaco3&out=(xcaco3&in*q&in)/q&out

xcapo4&out=(xcapo4&in*q&in)/q&out

xmgco3&out=(xmgco3&in*q&in)/q&out

xmghpo4&out=(xmghpo4&in*q&in)/q&out

sza&out=(sza&in*q&in)/q&out

szb&out=(szb&in*q&in)/q&out

xza&out=(xza&in*q&in)/q&out

xzb&out=(xzb&in*q&in)/q&out

!struvite edits

xmgnh4po4&out=(xmgnh4po4&in*q&in + 0.702*(18/14)*snh&in*q&in + 0.9*(95/31)*sp&in*q&in + 0.253*smg&in*q&in + 0.001089*q&in*1000000)/q&out

```
snh&out=(0.298*snh&in*q&in)/q&out
sp&out=(0.1*sp&in*q&in)/q&out
smg&out=(0.747*smg&in*q&in)/q&out
hmend
macro end
```

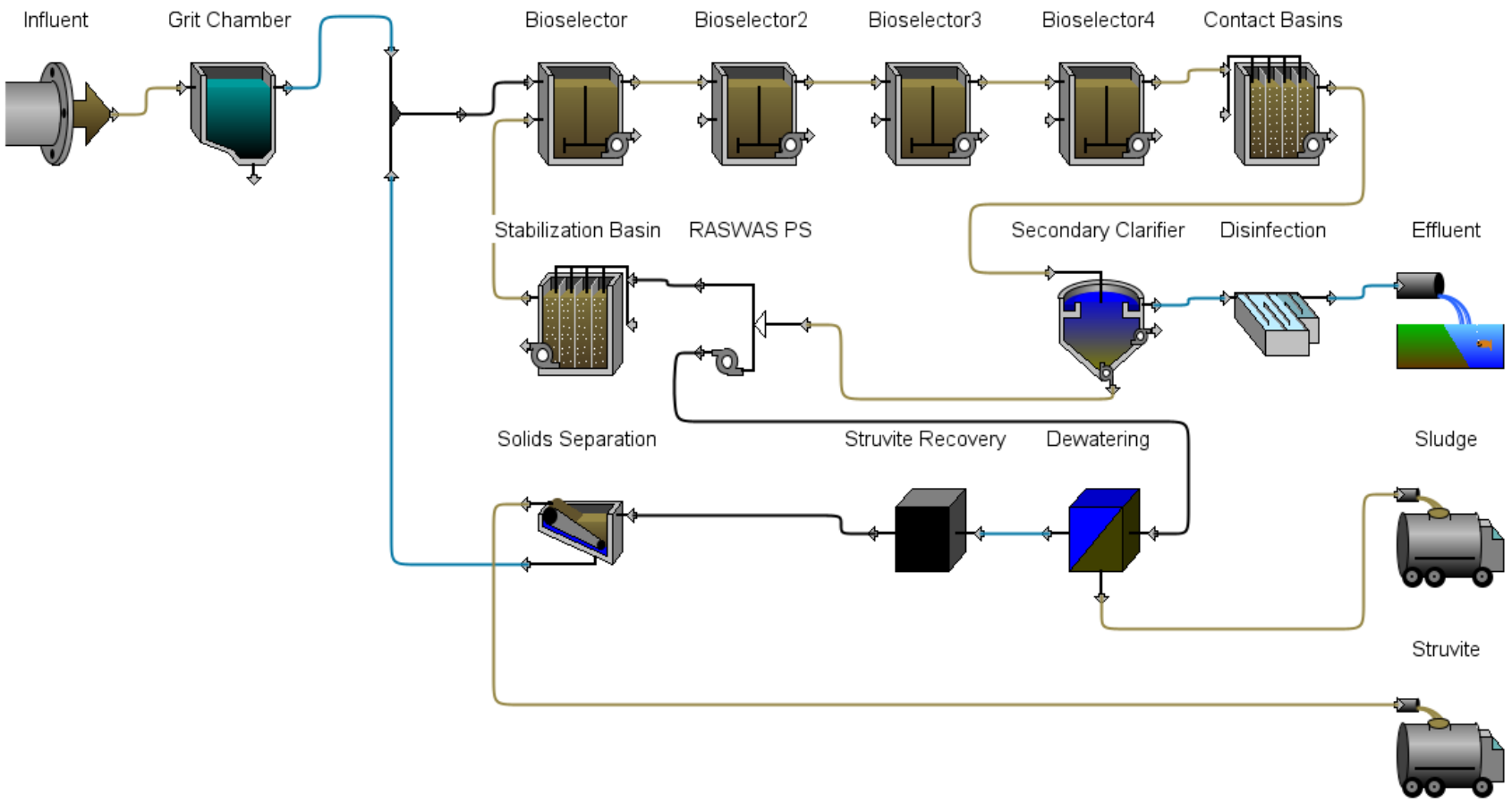


Figure S1. Process flow diagram of P street plant with electrochemical struvite recovery (B2-45, B2-90, B3-45, and B3-90 scenarios). No additional Mg dose is provided in these scenarios as soluble Mg is present in excess (influent value).

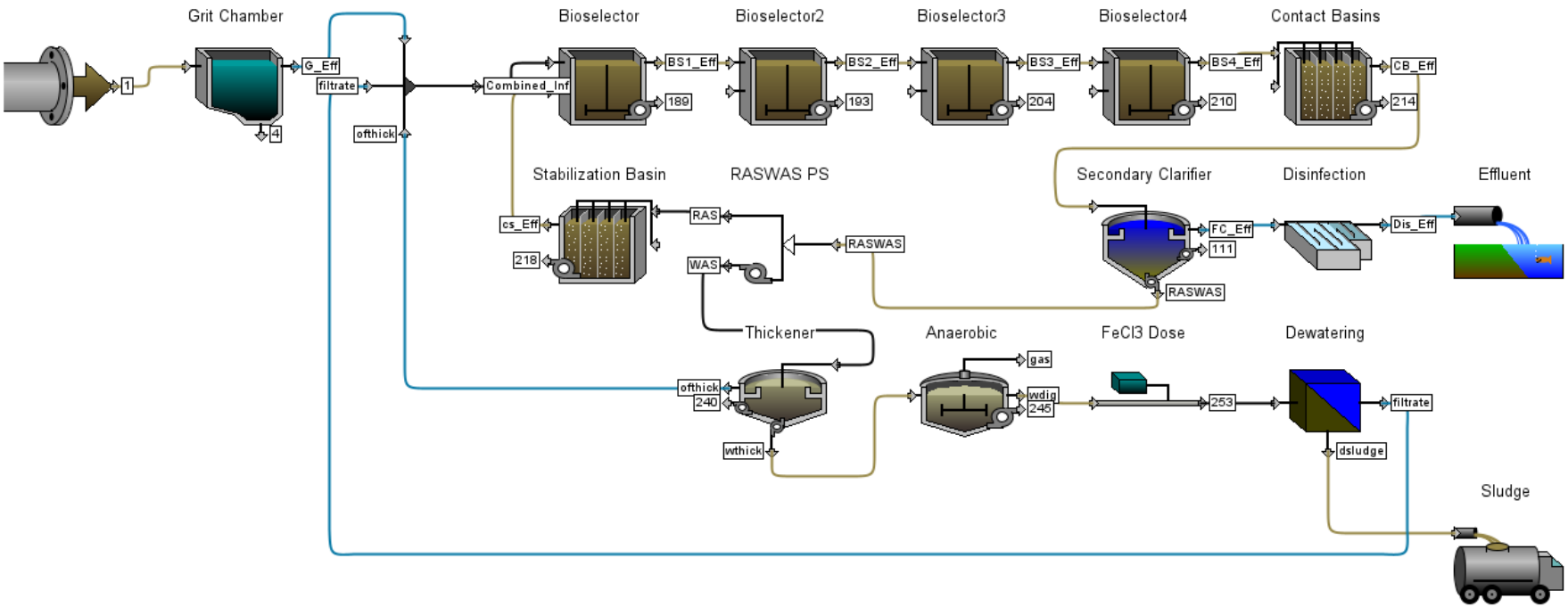


Figure S2. Process flow diagram of P street plant with added anaerobic digester (A1 scenario).

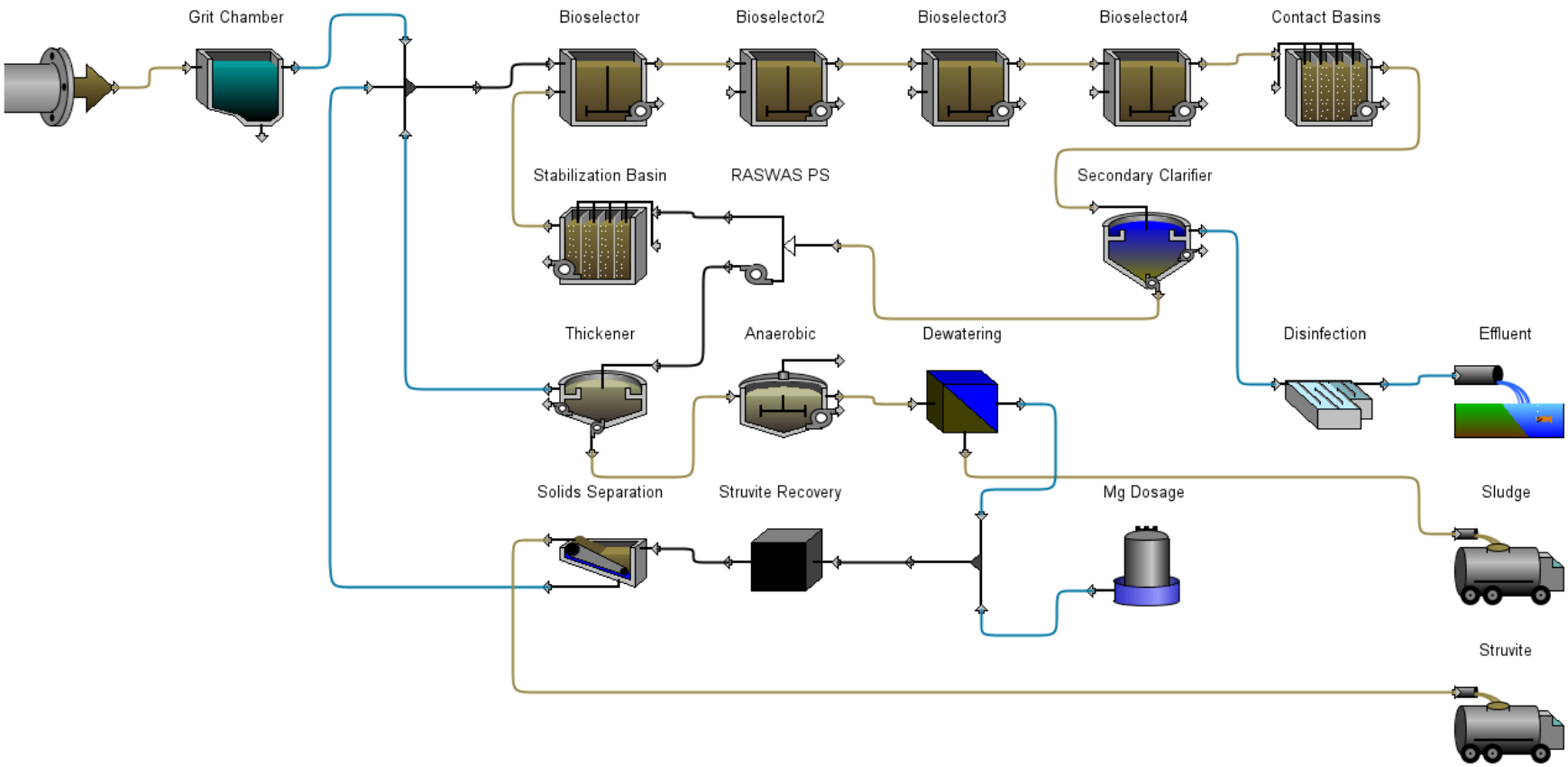


Figure S3. Process flow diagram of P street plant with anaerobic digester and electrochemical struvite recovery (A2-45, A2-90, A3-45, and A3-90 scenarios). A Mg dosage is included in these scenarios to provide excess soluble Mg for the struvite precipitation reaction.

Table S1. Life cycle inventory of wastewater treatment scenarios.

Influent		**B1**	**B2-45**	**B2-90**	**B3-45**	**B3-90**	**A1**	**A2-45**	**A2-90**	**A3-45**	**A3-90**
Wastewater influents	m3/hr	1893	1893	1893	1893	1893	1893	1893	1893	1893	1893
Total phosphorus	kg/hr	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36
Ammonia, as N	kg/hr	20.82	20.82	20.82	20.82	20.82	20.83	20.82	20.82	20.82	20.82
Raw materials/energy inputs											
Pure Magnesium Plate (Mg 99.9%)	kg/hr	-	0.0001	0.0002	0.0001	0.0002	-	3.18	5.73	3.18	5.73
Total Electricity (not including electrochemical reactor)	kWh	367.9	370.7	369.8	370.7	369.8	394.6	393.6	386.5	393.6	386.5
Electrochemical Reactor Electricity	kWh	0.00	0.00	0.01	0.00	0.01	-	74.5	134.6	74.5	134.6
Electricity, H_2 compression	kWh	-	-	-	0.00005	0.00010	-	-	-	1.52000	2.74000
$FeCl_3$	kg/hr	-	-	-	-	-	22.4	-	-	-	-
Outputs											
Struvite	kg/hr	-	0.00056	0.0011	0.00056	0.00111	-	16.2	29.25	16.2	29.25
Hydrogen gas	kg/hr	-	-	-	0.00001	0.00001	-	-	-	0.180	0.325
Biogas, from anaerobic digester	m3/hr	-	-	-	-	-	47.00	46.45	47.38	46.45	47.38
Heat from biogas per hour	kWh	-	-	-	-	-	124.40	123.20	125.30	123.20	125.30

Supplement heat required for digester, natural gas	kWh						9.82	13.32	8.75	13.32	8.75
Electricity from biogas per hour	kWh	-	-	-	-	-	89.09	88.26	89.74	88.26	89.74
Carbon dioxide, kg CO_2 eq, release to air	kg/hr	745.2	745.6	746.0	745.6	746.0	834.0	805.9	777.9	805.9	777.9
Sulphur dioxide, emissions to air from biogas	g/hr	-	-	-	-	-	19.21	19.03	19.35	19.03	19.35
Nitrogen oxides, emissions to air from biogas	g/hr	-	-	-	-	-	155.25	153.77	156.38	153.77	156.38
NMVOC, emissions to air from biogas	g/hr	-	-	-	-	-	7.69	7.61	7.74	7.61	7.74
CH_2O, emissions to air from biogas	g/hr	-	-	-	-	-	6.69	6.62	6.74	6.62	6.74
Soluble-P, release to water	kg/hr	0.02	0.02	0.02	0.02	0.020	0.02	0.03	0.02	0.03	0.02
Total phosphorous, release to water	kg/hr	1.92	1.92	1.92	1.92	1.92	2.07	2.45	2.07	2.45	2.07
Ammonia, as N, release to water	kg/hr	0.36	0.36	0.36	0.36	0.36	0.30	0.30	0.32	0.30	0.32
Mg, release to water	mg/hr	-	-	-	-	-	-	-	-	-	-
BOD_5, release to water	kg/hr	22.5	22.4	22.5	22.4	22.5	23.0	19.4	23.7	19.4	23.7
COD, release to	kg/hr	88.7	88.7	88.8	88.7	88.8	90.2	85.2	91.0	85.2	91.0

water											
Total nitrogen, release to water	kg/hr	7.06	7.06	7.08	7.06	7.08	9.68	8.64	8.11	8.64	8.11
Calcium carbonate, release to water	kg/hr	145.8	145.8	145.7	145.8	145.7	139.7	142.4	144.7	142.4	144.7
Sludge, to landfill	kg/hr	918.1	919.4	921.5	919.4	921.5	726.0	654.2	628.5	659.2	635.2
Total phosphorus, release to soil	kg/hr	7.04	7.03	7.04	7.03	7.04	7.24	4.82	4.11	4.82	4.11
Ammonia, as N, release to soil	kg/hr	0.00	0.00	0.00	0.00	0.00	0.73	0.60	0.63	0.60	0.63
Mg, release to soil	kg/hr	-	-	-	-	-	-	-	-	-	-
BOD_5, release to soil	kg/hr	62.1	62.1	62.0	62.1	62.0	14.8	15.7	15.1	15.7	15.1
COD, release to soil	kg/hr	161.4	161.4	161.3	161.4	161.3	85.4	86.1	84.5	86.1	84.5
Total nitrogen, release to soil	kg/hr	10.48	10.47	10.47	10.47	10.47	6.92	7.03	6.80	7.03	6.80
Calcium carbonate, release to soil	kg/hr	0.07	0.07	0.07	0.07	0.07	2.09	2.37	2.19	2.37	2.19
kg CO_2 eq, release to air	kg/hr	745.2	745.6	746.0	745.6	746.0	834.0	805.9	777.9	805.9	777.9

Table S2. Input parameters used in CapdetWorks software, (2022 $'s).

Cost Parameters	Value	Units	Source
Building cost	$260.00	$/sqft	[54]
Excavation	$25.00	$/cuyd	[54]
Wall Concrete	$750.00	$/cuyd	[54]
Slab Concrete	$500.00	$/cuyd	[54]
Crane Rental	$250.00	$/hr	[54]
Canopy Roof	$150.00	$/sqft	[54]
Hand Rail	$160.00	$/ft	[54]
Construction Labor Rate	$23.58	$/hr	[55]
Operator Labor Rate	$18.63	$/hr	[56]
Administration Labor Rate	$46.09	$/hr	[56]
Laboratory Labor Rate	$18.63	$/hr	[56]
Ferric Chloride	$0.00	$/kg	[57]
Magnesium Metal	$6.15	$/kg	[58-60]
Electricity	$0.06	$/kWh	[61]
Natural Gas	$9.23	$/kWh	[62]
Land Costs	$10,276.98	$/acre	[63-64]
Distance to Sludge Disposal Site	13.0	miles	[65]
Daily Sludge Handling Operation Hours	10.0	hr	[65]
Loading Time per Vehicle	2.0	hr	[65]
Hauling Time per Trip	1.5	hr	[65]
Sludge Disposal Cost	$44.11	$/US Ton	[66]
Interest Rate	8	%	[51,67-68]
Construction Period	3	years	[51,67-68]
Operating Life of Plant	40	years	[51,67-68]
Engineering Design Fee	15	%	[51,67-68]
Miscellaneous	5	%	[51,67-68]
Administration/Legal	2	%	[51,67-68]
Inspection	2	%	[51,67-68]
Contingency	10	%	[51,67-68]
Technical	2	%	[51,67-68]
Profit and Overhead	15	%	[51,67-68]

Table S3. Parameters used in hydrogen compression calculations. Values derived from Khan et al., 2021 [76] and outputs from GPS-X.

Parameter	Value	Unit
Compressor stages (N)	5	
Discharge pressure (Pdisc)	200	bar
Suction/inlet pressure (Psuc)	1	bar
Average pressure (Pavg)	100.500	bar
Suction/inlet temperature (Tsuc)	305.150	K
Discharge temperature (Tdisc)	488.686	K
Average temperature (Tavg)	396.918	K
Compression ratio for single stage (x)	3.05	
Specific heat ratio (k)	1.41	
Isentropic efficiency (nisen)	0.6	
Compressibility factor (Z)	1.0334	
Molar flow rate (qM B3-45)	8.664E-07	moles/sec
Molar flow rate (qM B3-90)	1.714E-06	moles/sec
Molar flow rate (qM A3-45)	0.0250183	moles/sec
Molar flow rate (qM A3-90)	0.0451719	moles/sec
Universal gas constant (R)	8.314	J/mol.K
Motor efficiency	0.95	

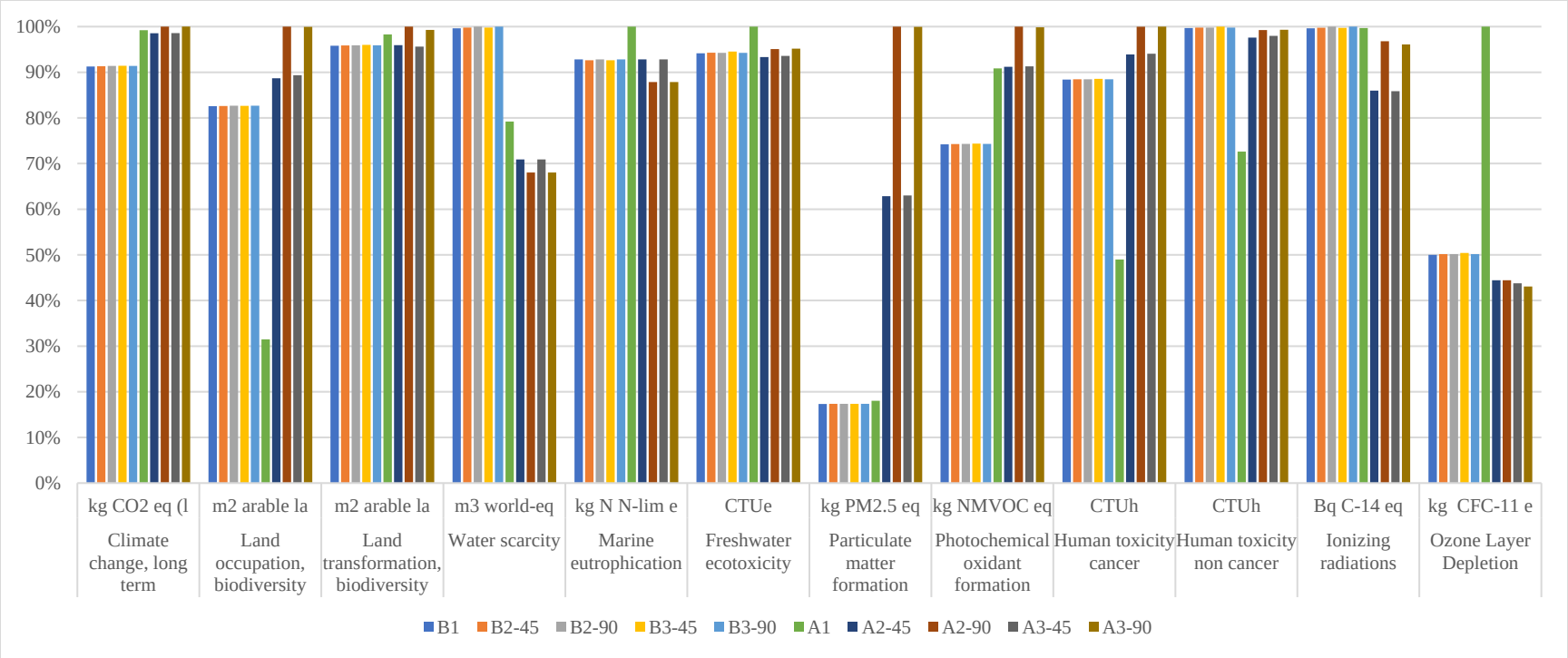
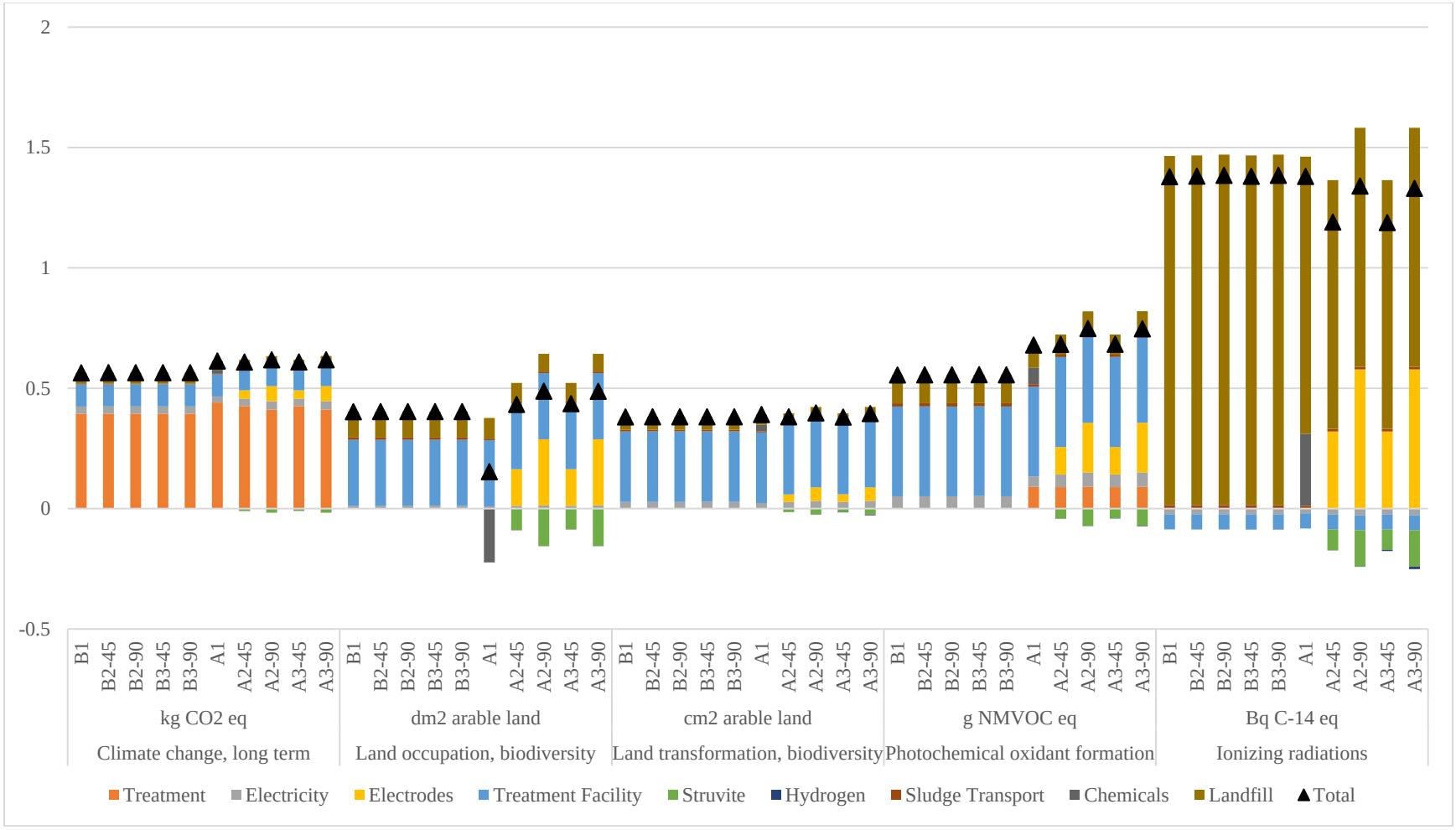
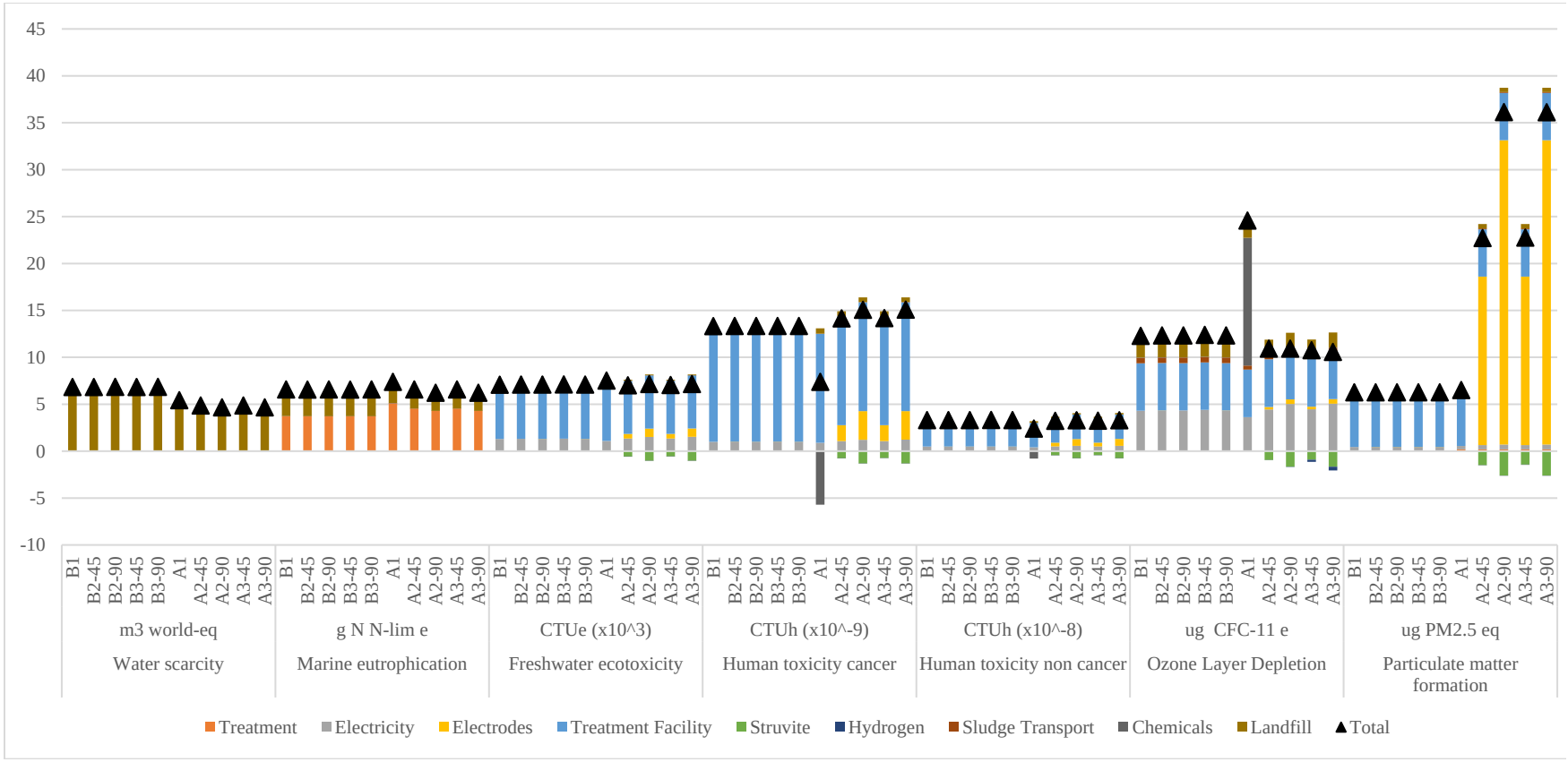


Figure S4. Life cycle impact assessment (IMPACT World+, remaining 12 categories).


2
1.5
1
0.5
0
-0.5
B1
B2-45
B2-90
B3-45
B3-90
A1
A2-45
A2-90
A3-45
A3-90
kg CO2 eq
Climate change, long term
dm2 arable land
Land occupation, biodiversity
cm2 arable land
Land transformation, biodiversity
g NMVOC eq
Photochemical oxidant formation
Bq C-14 eq
Ionizing radiations
Treatment
Electricity
Electrodes
Treatment Facility
Struvite
Hydrogen
Sludge Transport
Chemicals
Landfill
Total

(**a**)



(**b**)

Figure S5. (**a**,**b**) Full Process Contribution Analysis for All Impact Categories (IMPACT World+).