Agricultural Water Management

NSW Department of Primary Industries

Shoalhaven Starches Pty Ltd

SHOALHAVEN STARCHES ETHANOL UPGRADE

FITNESS FOR PURPOSE OF TREATED WASTEWATER

AGRONOMIC INVESTIGATIONS

SUPPLEMENTARY INFORMATION INCLUDING MONITORING PROGRAM

Prepared for Shoalhaven Starches Pty Ltd

and

Cowman Stoddart Pty Ltd

by

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SHOALHAVEN STARCHES SUPPLEMENTARY AGRONOMIC INVESTIGATIONS

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S. SUMMARY

The proposed upgrade of the ethanol plant at the Shoalhaven Starches Facility at Bomaderry will alter the quantity and chemical composition of wastewater that is used for irrigation on the associated Environment Farm. This report provides supplementary information to an earlier report (Murtagh, Lawrie and Lugg June 2008) that concluded that the combined wastewater flows from the sulphur oxidation basin and the retentate from the wastewater treatment plant could be used for irrigation.

In response to a request from the regulatory authorities, the current report was prepared to confirm how the irrigation program will be implemented, to provide details of the mass balance of various analytes in the wastewater, and to detail the monitoring program that will confirm how the irrigation is affecting the Farm environment.

The mass balances showed that the balance between inputs from wastewater and losses in silage that is harvested from the Farm would be:

- Positive for phosphorus, magnesium, sodium, bicarbonate, chloride and sulphate. That is more of these analytes will be added than will be removed in silage.
- Balanced for calcium.
- Negative for nitrogen and potassium.

Of the six analytes with a positive balance, only sodium and chloride are likely to strongly leach and this was viewed as desirable to limit the development of soil salinity. Nor did they contribute to environmental harm because of the saline nature of the receiving waters and subsoil. Of the remaining four analytes, most if not all of the phosphorus, magnesium and bicarbonate will precipitate in the soil, while some of the sulphate will precipitate or form acid and some might leach. Leaching sulphate will not be detectible because of the considerable quantity of sulphate compounds and ions in the acid sulfate environment.

The negative mass balances with nitrogen and potassium indicate that they will not leach and will not constitute an environmental risk, but will have implications for plant nutrition.

The proposed monitoring program included:

- Documenting the volume and chemical composition of the wastewater to confirm the mass of each analyte that will be added to the Farm;
- Annual soil monitoring to determine the time trends in the concentration of those analytes that are likely to accumulate in the soil, or to be important for plant nutrition;
- Monitoring of the chemical composition of herbage to document the removal of selected nutrients and the need for fertiliser use;
- Monitoring groundwater to detect leaching of surplus magnesium, this being the only analyte that is likely to leach and that is not already common in the receiving waters.

Details are also provided of the remedial measures that should be implemented should the various analytes accumulate to undesirable levels.

S1. Checklists

The first table provides a checklist of the required actions for monitoring and related issues. It also details the sections in the report where more detail is provided.

Item	Reason	Frequency	How	Section
WASTEWATER				
Irrigation volume	Used in mass load calculations	As used	Flowmeters	4.1
Composition – suite A high concentration	Identify surplus	Monthly	Chemical analyses	4.1
Composition – suite B low concentration	Identify deficit and need for fertiliser	Monthly	Chemical analyses	4.1
SOIL				
Composition– suite C	Detect changes over time	Annual	Soil cores (0-30cm)	4.2
Soil structure	Maintain structure	Annual	Dispersion test	4.2
HERBAGE- HARVESTED				
Harvested quantity	Used in mass removal calculations	At each harvest	Bale count by average weight	4.3
Composition - suite D	Mass removal and need for fertiliser	All cuts (bulked)	Chemical analysis	4.3
HERBAGE - GRAZED				
Animal grazing days	Used in mass removal calculations	Ongoing	Counts	4.3
Composition - suite D	Mass removal and need for fertiliser	Annual	Leaf plucks & chemical analysis	4.3
GROUNDWATER				
Composition– suite E	Detect leaching due to surplus	Annual	Chemical analyses	4.4
REMEDIATION				
Response	Correct undesirable effects	As required	Recommendations	3

Suite A chem. testing, high conc. – pH, EC, Mg, Na, HCO_3, Cl, SO_4.

Suite B chem. testing, low conc. – total N, total P, K, Ca.

Suite C chem. testing, soil – pH, EC, total P, K, (Exch.Ca, Mg, K, Na), soluble Na, Cl.

Suite D chem. testing, herbage – total N, P, K, Ca, Mg.

Suite E chem. testing, groundwater – Mg.

The second table outlines the key issues for operational planning, and where details may be found.

Item	Aim	How	Section
Crop types	Maintain high productivity	Continue with existing ryegrass and kikuyu pastures	
Pasture productivity	Maintain high productivity	Use fertiliser and overseeding as required	3
Irrigation	Avoid overwatering	Deficit irrigation	First report 7.3
Soil quality	Avoid unacceptable salt accumulation	Monitor and change inputs or outputs where required	4
Nutrient removal	Reduce accumulation of surplus analytes in soil	Cut and removal of herbage	3

1. INTRODUCTION

The authors of the current report previously completed a study on the agronomic issues related to the Shoalhaven Starches Ethanol Upgrade and the use of wastewater for irrigation on the Shoalhaven Starches' Environmental Farm (Murtagh, Lawrie and Lugg June 2008). Their report was reviewed at a meeting held at Bomaderry on 20 June 2008. The meeting was attended by representatives of the Department of Environment and Climate Change (DECC), Department of Planning, Shoalhaven Starches Pty Ltd, Cowman Stoddart Pty Ltd and the authors of the report.

While the contents of the June 2008 report were generally accepted, the meeting indicated that further information was required to progress the proposal to apply wastewater from the upgraded plant to the Environmental Farm. In essence the DECC wanted to be assured that the proposal is environmentally sustainable. Towards that end their representatives indicated that three issues needed to be addressed:

- What needs to be done to implement the proposed program;
- What nutrients are removed by the crops grown on the Environment Farm;
- What monitoring is required.

The following report addresses these issues.

2. WASTEWATER – AMOUNT AND COMPOSITION

Two wastewater streams will be combined and used for irrigation:

- Discharges from the sulphur oxidation basin amounting to 2.1 ML/d;
- The retentate flow from the wastewater treatment plant amounting to 1.5 ML/d.

The June 2008 report considered the impact of using none, 50%, or all of the retentate for irrigation and concluded that all could be used. Hence this report built on that conclusion and used a wastewater flow of 3.6 ML/d.

The composition of blended wastewater, taken from the June 2008 report, is listed in Table 1.

Table 1 Chemical composition of the wastewater.

Item	Unit	Amount
Total flow	ML/d	3.6
TDS	mg/L	2,606
TDS load *	t/ha/yr	7.0
Ca^{++}	mg/L	15
Mg^{++}	mg/L	267
Na^{+}	mg/L	168
K^{+}	mg/L	23
HCO_3^{--}	mg/L	1742
SO_4^{--}	mg/L	51
Cl^{-}	mg/L	225
NO_3^{-}	mg/L	55
PO_4^{+++}	mg/L	60

3. MASS BALANCES AND REQUIRED MONITORING ON ENVIRONMENT FARM

The current study used mass balances to document the input/output relations on the Environment Farm for relevant analytes in the wastewater, and to identify the dominant processes that require monitoring. The general aim was to show where each analyte is likely to end up and whether the process is environmentally sustainable. The mass balances only formally addressed the analytes from wastewater and not the general soil supply of nutrients to plants, although some comments were given on the implications for plant nutrition. Many of the analytes that were covered in the report would be rated as plant nutrients, but others such as chlorides would be viewed as potential contaminants.

The Environment Farm is used to grow ryegrass or kikuyu pasture that is cut for silage. As that material is removed from the Farm, the harvesting constitutes an important removal process. The average silage yield over three years was 7.64 t dry matter per hectare per year, which was used for the mass-balance calculations. The on-going monitoring should include a record the annual silage yield.

The analyte concentrations in silage were taken from one of two groups:

- A high concentration was used when the soil was rich in an analyte, as would be experienced under conditions of luxury uptake. This applies to a number of analytes under current conditions on the Environment Farm, and typical concentrations are given in the June 2008 report.
- Average concentrations were used when the soil had lower concentrations of the analyte.

The required monitoring is only given in general terms in this section, with more detail coming later. For instance soil monitoring will sometimes entail measuring both the total concentration and also the available or exchangeable concentration. The wastewater must be monitored sufficiently to keep track of inputs to the Farm and changes in the production process.

Since the irrigation system is managed according to the principles of deficit irrigation, all of the irrigation water enters the soil and there is no surplus that would run off. As a result all the applied analytes also enter the soil and will be inaccessible to later runoff that can occur after rain. Consequently no provision for runoff losses were included in the following mass balances.

3.1 Nitrogen

The nitrogen mass balance is given in the following Table. The application amount was based on the expected concentration in wastewater (Table 1) and the removal rate in silage was based on recent measurements (June 2008 report).

Table 2 Nitrogen mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 12.4 mg/L / 487 ha	33
Volatilisation losses	25%	-8
Removed - silage	7.64 t/ha/yr * 31 mg/g	-237
Input/output balance		negative
Leaching		nil

The mass balance shows a large imbalance between the expected nitrogen input and the current removal in silage. Note also that some nitrogen will be lost through volatilisation.

The recent nitrogen concentration in silage was within the normal range and unless fertiliser is used to apply additional nitrogen, both the silage yield and nitrogen concentration in the silage will drop. This is an important issue because the large silage yield is important for removing quantities of other analytes from the Farm.

Monitoring

Under these circumstances, the monitoring should be used to confirm that the wastewater adds little nitrogen, and the removal rate should be monitored as an aid for fertiliser use. Items to be monitored are:

- Wastewater
- Silage (or tissue N if paddock is grazed rather than cut for silage)

Soil monitoring of nitrogen was not included because the large quantity of background nitrogen obscures changes in available nitrogen. Tissue analyses give a better understanding of available levels and when there are large amounts that could induce nitrogen leaching.

Remedial actions

In the unlikely event that the tissue sampling shows a luxury concentration of nitrogen (greater than 45 mg/g), the following actions should be taken:

- Ensure that the maximum amount of forage is cut and removed from the paddock as silage or hay. This will maximise the nitrogen removal rate;
- Begin monitoring the groundwater for nitrates to test whether nitrogen is leaching;
- Reduce the irrigation rate where possible.

3.2 Phosphorus

Table 3 Phosphorus mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 19.9 mg/L / 487 ha	54
Removed - silage	7.64 t/ha/yr * 4.46 mg/g	-34
Input/output balance		+20
Leaching		nil

Past applications of phosphorus in wastewater created a large soil store. As a consequence the grasses have luxury uptake and remove a relatively large quantity of phosphorus. Nevertheless, the wastewater will apply surplus phosphorus, and whilst this is expected to bind to the soil based on past experience, ongoing monitoring is required to confirm that this is happening.

Monitoring

Monitoring is required to confirm that the surplus phosphorus is being bound to the soil and not leaching. The monitoring should document the total phosphorus concentrations in:

- Wastewater
- Soil
- Silage

Should the phosphorus concentration in the surface soil increase significantly over time, monitoring should be expanded to examine the phosphorus concentration at depth at the annual sampling sites (Section 4.2). The current sampling for phosphorus by depth at the rotating sites should also continue. The sampling by depth will reveal whether phosphorus is leaching down the soil profile.

Remedial actions

If tests show that phosphorus is moving down the soil profile, remedial actions are:

- Ensure that the maximum amount of forage is cut and removed from the paddock as silage or hay. This will maximise the phosphorus removal rate;
- Begin monitoring the groundwater for phosphorus to test whether phosphorus is leaching;
- Examine the potential to reduce the phosphorus concentration within the ethanol plant;
- Reduce the irrigation rate where possible.

3.3 Potassium

Potassium is not normally viewed as a potential contaminant but is included here because of its importance as a plant nutrient.

Table 4 Potassium mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 23 mg/L / 487 ha	62
Removed - silage	7.64 t/ha/yr * 41.4 mg/g	-316
Input/output balance		negative
Leaching		nil

The main issue with potassium is the large negative input/output balance and its implications for plant nutrition and the need to apply fertiliser. Under current conditions, the grasses have a generous supply of potassium which is reflected in the high silage concentration of 41 mg/g. With the limited application of potassium from the proposed wastewater, the potassium concentration will be at least halved resulting in a reduction in the input/output balance but it will still be negative and fertiliser will be required.

Monitoring

No monitoring is required from the contamination perspective, but the following are recommended as aids for developing a fertiliser regime:
- Wastewater
- Soil
- Silage

Remedial actions
Apply potassium fertiliser as required.

3.4 Calcium

Table 5 Calcium mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 15 mg/L / 487 ha	41
Removed - silage	7.64 t/ha/yr * 5.3 mg/g	-40
Input/output balance		balanced
Leaching		nil

The balanced mass balance indicates that the grasses will remove about the same amount of calcium that will be applied, and hence the ongoing wastewater irrigation will have little direct impact. As discussed elsewhere however, some calcium salts are likely to precipitate from the soil solution, but given the very large existing soil store of calcium this process can proceed for many years without impact.

Monitoring

No monitoring is required from the contamination perspective, but as calcium is an important component on the exchange complex, application amounts and soil monitoring (exchangeable calcium) are recommended. The concentration in silage is also required to monitor the removal rate:
- Wastewater
- Soil
- Silage

Remedial actions

Apply lime or gypsum where necessary to increase the proportion of calcium on the exchange complex, or to improve soil structure. Use lime if a pH increase is also desirable, otherwise use gypsum.

3.5 Magnesium

Table 6 Magnesium mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 267 mg/L / 487 ha	721
Removed - silage	7.64 t/ha/yr * 1.72 mg/g	-13
Input/output balance		+708
Leaching		nil or slight

The wastewater will add a considerable quantity of magnesium but as discussed in the June 2008 report there is considerable scope to reduce the amount should that prove to be desirable. The removal rate in silage will account for about 2% of the application rate leaving a considerable surplus in the soil.

Some, and perhaps much, of the surplus magnesium will precipitate out in the soil thus reducing its impact. This precipitation together with the general immobility of magnesium will limit, if not stop, the magnesium leaching to deep layers.

Monitoring

As discussed in the June 2008 report, surplus magnesium can cause nutrient imbalances for plants and soil structural problems, and the recommended monitoring was designed to detect adverse trends in these aspects.

- Wastewater
- Soil (including dispersion)
- Silage
- Groundwater

Remedial actions

If tests show that magnesium is becoming dominant on the exchange complex, remedial actions are:

- Investigate the potential to reduce the magnesium concentration within the ethanol plant;
- Ensure that the maximum amount of forage is cut and removed from the paddock as silage or hay. This will maximise the magnesium removal rate;
- Apply gypsum to increase the proportion of calcium on the exchange complex, and to improve soil structure should the dispersion test prove to be unsatisfactory;

3.6 Sodium

Table 7 Sodium mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 168 mg/L / 487 ha	454
Removed - silage	7.64 t/ha/yr * 5.42 mg/g	-41
Input/output balance		+413
Leaching		413

The silage removed 9% of the applied sodium, leaving 413 kg/ha/yr in the soil. Because of the general mobility of sodium ions and salts, it was assumed that all of the surplus sodium would leach. Given that both the groundwater and receiving waters are brackish, the addition of this relatively small amount of sodium was not viewed as constituting environmental harm and in fact the ongoing leaching of sodium should be encouraged to maintain soil health.

Monitoring

The main environmental issues with sodium relate to soil sodicity and salinity, and the monitoring was designed to detect any trends in these directions. It is not important to monitor the removal of sodium since the accumulation of sodium in soil is the issue to be watched.

- Wastewater
- Soil (EC, soluble, exchangeable and dispersion)

Remedial actions

- Apply surplus water using one or more irrigations (leaching irrigation) to leach sodium from the soil.

3.7 Bicarbonate

Table 8 Bicarbonate mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 1741 mg/L / 487 ha	4703
Removed - silage		nil
Input/output balance		+4703
Leaching		doubtful

The alkaline nature of bicarbonate is viewed as a positive given the common presence of acid production from local acid sulfate soils. Continued application of large quantities of bicarbonate can also cause calcium and magnesium to precipitate as carbonates. This would also be a positive with the ongoing application of magnesium, and for a number of years the large store of calcium in the soil store would offset any precipitation of this element. It is not thought that any of the bicarbonates would leach and even if they did their presence could not be detected in the brackish groundwater.

Monitoring

The soil monitoring should be directed towards the consequences of bicarbonate application, rather than directly assaying for bicarbonate:

- Wastewater
- Soil (pH)

Remedial actions

If there is evidence that continued application of large amounts of bicarbonates is reducing the available calcium or magnesium:

- Use fertiliser to apply additional calcium or magnesium;

- Investigate the potential to reduce the bicarbonate concentration within the ethanol plant.

3.8 Chloride

Table 9 Chloride mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 225 mg/L / 487 ha	608
Removed - silage	7.64 t/ha/yr * ~2 mg/g	-15
Input/output balance		+593
Leaching		593

The silage removed a small proportion of the applied chloride, leaving 593 kg/ha/yr in the soil. Because of the general mobility of chloride ions and salts, it was assumed that all of the surplus chloride would leach. Given that both the groundwater and receiving waters are brackish, the addition of this relatively small amount of chloride was not viewed as constituting environmental harm and in fact the ongoing leaching of chloride should be encouraged to maintain soil health.

Monitoring

The main environmental issue with chloride relates to soil salinity, and the monitoring was designed to detect any adverse trends.

- Wastewater
- Soil

Remedial actions

- Apply surplus water using one or more irrigations (leaching irrigation) to leach chloride from the soil.

3.9 Sulphur (sulphate)

Table 10 Sulphur mass balance.

Process	Detail	Flux (kg/ha/yr)
Applied	3.6 ML/d * 17 mg/L / 487 ha	46
Removed - silage	7.64 t/ha/yr * 2.28 mg/g	-17
Input/output balance		+29
Leaching		some

The sulphur mass balance showed that some of the applied sulphur was removed in silage. The remaining 29 kg/ha/yr could either bind as the sulphate ion to form acid or a salt, or leach as sulphate to lower layers.

Monitoring

Since the large background presence of sulphates would mask the small amount from wastewater, there would be no point in attempting to monitor the contribution from wastewater. Accordingly the recommended monitoring was limited to the inputs from wastewater:

- Wastewater

Remedial actions

- Apply lime if there is a pH drop associated with sulphate accumulation.

3.10 Mass balance summary

The mass balances showed that the balance between inputs from wastewater and losses in silage would be:

- Positive for phosphorus, magnesium, sodium, bicarbonate, chloride and sulphate.
- Balanced for calcium.
- Negative for nitrogen, and potassium.

Of the six analytes with a positive balance, only sodium and chloride are likely to strongly leach and this was viewed as desirable to limit the development of soil salinity. Nor did they contribute to environmental harm because of the saline nature of the receiving waters. Whilst magnesium is unlikely to leach to any extent and is also present in the receiving waters, there will be a large surplus and monitoring of both the soil and groundwater should be used to detect where it accumulates. Monitoring will be required to assess the effects of ongoing additions of phosphorus and bicarbonate, while the sulphate additions will be masked by the background levels,

The negative mass balances with nitrogen and potassium will have implications for plant nutrition.

4. DETAILS OF MONITORING

4.1 Wastewater

It is important that the wastewater be analysed on a regular basis to obtain an accurate record of applications to the Environment Farm. Monthly sampling is recommended but it is understood that more frequent sampling is required to meet licence conditions. Recognising that various waste streams are blended over time, the samples should be taken from the irrigation pipes rather than sampling from the storage ponds.

Items to be monitored are:
- Irrigation volumes (as per current)
- Chemical composition – pH, EC, total N, total P, potassium, calcium, magnesium, sodium, bicarbonate, sulphate, chloride.

Note that nitrate analysis was not included above, the reason being that the nitrogen mass balance showed that there was no environmental risk from nitrogen supplies and given the complications of sampling for nitrate it is not worth the effort.

4.2 Soil

The existing soil testing program should be continued because it provides a long-term description of trends in soil chemistry. The existing program includes profile sampling from two paddocks each year following a three-year paddock rotation around the irrigation areas. This gives two samples, by depth, each year.

In addition, a supplementary soil monitoring program should be instigated to:
- Monitor analytes that are not covered by the existing program;
- Sample annually from two fixed positions to provide an uninterrupted time trend of changes in chemical composition;
- Confine this program to surface soil, as issues that require profile sampling are already catered for in the existing soil testing program.

Since the main objective of the supplementary monitoring is to detect changes in soil composition over time rather than describing the soil composition across the total irrigated area, it is recommended that the annual monitoring be concentrated within two sampling sites. This will provide more consistent estimates of the annual trends than sampling over a wider area.

Two important issues are:

- Restrict each sampling zone to a reasonably small area by defining a fixed area of about 500 m^2 and always take samples from within this area. The fixed-area sampling has the advantage that the sample mean will have less variation that one based on a larger area, leading to an increase in ones' ability to detect changes over time in the various measurements.

- Take sufficient samples from within a sampling area to get an accurate estimate of the mean. Each group of samples can be bulked so that they will be analysed by a single chemical test. The important point is that they be drawn from a number of positions to average out the natural variation within the sampling area.

It is recommended that the sampling use the following routine:

- Use two sampling areas. The areas should be reasonably representative of the irrigated paddocks as a whole and receive an average application of wastewater. Each area should be about 500 m^2 and they must be easily located.

- At each sampling area, take 10 cores of the surface soil. The sampling must cover the full sampling area and avoid unrepresentative spots eg bare soil. Bulk and mix the soil samples and take a single sub-sample for chemical tests.

Thus the soil sampling will produce two samples for chemical tests.

In the absence of control areas that have received no chemical inputs from wastewater and are matched with the sampling areas, the time trends in the concentrations of the various analytes will provide the main basis for detecting changes due to reuse irrigation.

Items to be monitored are:
- Chemical composition – pH, EC, total P, soluble sodium, chloride, exchangeable cations.
- Soil dispersion.

4.3 Plant tissue or silage

The removal rate of the various analytes represents an important component in the mass balances. The removal rate will be estimated from:
- Where herbage is cut and removed for silage, the removal rate equals the quantity removed times the herbage composition;
- Where herbage is grazed, the expected removal in animal tissue. While the herbage composition is not required for this calculation, the composition should still be monitored to assess general fertiliser requirements. More refined estimates would include nitrogen losses through volatilisation and nutrient redistribution in excreta that is deposited on unirrigated areas.

The weight of harvested material can be calculated from the number of bales removed, times the average weight of a bale. Records should be kept of the number of beast grazing days on the grazed areas.

To simplify the testing of plant tissue from harvested areas, samples can be taken from material cut for silage. The samples should consist solely of leaf material, with no stems, or alternatively include stems in chopped material but adjust using a typical leaf to stem ratio.

To provide consistency over time, as with soil testing, samples should be taken from the same position each year. A total of three test samples should be collected.

Since the tissue concentrations can vary over the year, samples should be taken from all silage cuts. The sequence of samples can be retained and bulked to obtain one representative sample (from each sampling position) for chemical analysis each year.

Leaf plucks should be taken from two, pre-set sampling sites within the grazed areas. The sampling should be done in early spring, before active growth commences. A single sampling per year will suffice while no problems are being encountered.

The samples are to be analysed for:
- Total nitrogen, phosphorus, potassium, calcium and magnesium.

4.4 Groundwater

The recommended chemical testing of groundwater is at a low intensity because:
- The deficit irrigation regime ensures there is no percolation after irrigation, and the interval between irrigation and heavy rain provides more time for chemicals to precipitate in the soil, bind to soil particles or be absorbed by roots.
- Some of the applied analytes (N, K and Ca) will have a balanced or negative mass balance and hence are unlikely to leach.
- Other applied analytes (Na, Cl and SO_4) that will leach are naturally present in substantial concentrations in the receiving waters.

Hence the only analyte to be monitored under this protocol is magnesium, and annual sampling will suffice unless elevated magnesium levels develop. Note that groundwater at reference sites is currently sampled as part of the existing monitoring program and this program should continue.

In order to mesh the two sampling regimes, the existing system of using the “CB” testwell to obtain control samples, and soil sampling holes to obtain groundwater at other sites should be continued. The change that the current investigation will introduce is to include tests for magnesium, and to collect groundwater samples from the two new sites that are to be introduced as part of the soil sampling program.

The sampling procedure from testwells is:
- Pump out the testwell no more than 24 hrs prior to sampling and allow sufficient time to recharge.
- Use a bailer to collect a sample from throughout the depth of inflow groundwater.
- Flush the sample bottle with sample and then fill to capacity leaving virtually no air space when capped. Obtain a smaller duplicate sample for retention.

The sampling procedure from groundwater at reference sites is:
- On the first hole, soil sample the first 20 cm. Continue to auger through to the groundwater. Mark hole and continue sampling the other profiles required for bulking at the reference site.
- Collect by pump or bailer the fresh groundwater made in the first hole.

Flush the sample bottle with sample and then fill to capacity leaving virtually no air space when capped. Obtain a smaller duplicate sample for retention.

5. REFERENCE

Murtagh, J., Lawrie, R. and Lugg, G (2008) Shoalhaven Starches Ethanol Upgrade: Fitness for Purpose of Treated Wastewater, Agronomic Investigations. Report prepared for Shoalhaven Starches Pty Ltd and Cowman Stoddart Pty Ltd, June 2008.