Instrument selection: a case study

Table 3 supports a structured consideration how instrument related and complementary issues were combined for this case study. We build groups of choice factors according to their importance on the decision making process for: instrument related factors, financial considerations, operational conditions and additional considerations. This Table enables the user to readily identify essential factors that could exclude an instrument from selection (-) and trade-off constraints (o) as well as factors that are acceptable (+) or highly acceptable (++). Those factors that most influence the decision making process were highlighted as underlined characters.

For this illustrative case study we first considered the project-specific factors. We concluded a priori not to choose a submersible wet chemistry analyser as they (i) are limited in high frequency analysis capacity to 4 weeks unattended operation and b) need two technicians for field servicing, which would unnecessarily increase maintenance costs. There were no limitations for power supply and phone reception as they were available on-site.

For the decision making process we compared project needs against the outlined factors showing individual progression steps (i-vii) for each of the choice groups:

1.) Ability to conduct high frequency measurements of the required N & P species at the expected concentration range with the necessary accuracy of not lower than 3% of range. The project sought a detailed consideration of species of N and P. A minimum of total nutrient concentrations and one species each of N and P was essential. The expected nutrient concentration ranges at this site were unusually wide for Tasmanian conditions but low compared to North-American or European standards. The detection limits of the instrument must accommodate the ambient nutrient concentrations, which are usually below 1 mg L^{-1} for dissolved species and less then 5 mg L^{-1} for total N and P. High frequency (hourly or lesser) measurement of nutrients was essential to enable use of data analysis techniques as described by Kirchner [22], Rusjan [26], Harris and Heathwaite [27], or Jordan et al. [21].

According to Table 3 we first compared instrument related factors to judge whether the proposed analyser were able to meet these needs.

(i) As a first decision step we excluded some of these instruments (Numbers 1, 2 and 5) from further consideration, even though they have considerable advantages amongst other factors. The main issue was that they were not able to capture the expected concentration ranges due to given the detection limits.

(ii) Secondly we favoured instruments with customisable concentration ranges (Number 4, 9 and 6 for PO_4-P) and the capability of measuring all desired constituents (Number 4) within the appropriate level of accuracy.

(iii) However instruments with very rapid measurements and good accuracy were also considered despite the fact they were limited number in measured constituents (Number 8 and 9).

(iv) Other instruments were less suitable because their concentration ranges did not meet requirements (Number 3, 5, 8, and NO_3-N and NH_4-N for number 6).

At this step the instruments numbered 4 and 9 were considered as most favourable.

2.) Financial considerations

The costs associated with each of the proposed instruments were investigated as next decision making step. The budget for this installation is consistent with an intensive research orientated investigation. Multiple instruments could be purchased enabling complementarily between different instrument types. Major service items were possible within the maintenance component of the budget. Budget decisions were primarily tradeoffs between 3 or 4 instruments and maintenance costs over the life of the project. The costs had to be specifically weighed up against capability and suitability of instruments.

(v) Therefore the trade-off decision was whether to invest into suitable cost-intensive multi-parametric analysers (e.g. Number 4) or into less expensive instruments with limited monitoring parameter (e.g. Number 9).

3.) Operational conditions

As a next decision making step the technical feasibility for an installation of the proposed instruments were investigated. The site was located in a temperate environment with an annual mean temperature range of 4 to 20 ˚C. Budget constraints dictated a frequency of field maintenance of 4 weeks. Between field visits the instrument would be unattended and be monitored only via telemetry-enabled communication. The travel time to the field installation for the technicians is of the order of 5 hours, so that features of instruments that significantly reduce the risk of unscheduled travel were a consideration. The chosen sites were proved to be secure.

These frequencies of sampling need to be sustained for weeks at a time and preferably programmed via telemetry. We checked that adequate arrangements could be made for reagent preparation, and that the health and safety requirements for reagent transport, instrument operation and waste disposal could be met for the chosen site.
(vi) For all proposed instruments these requirements could be fulfilled. However the installation of a wet chemistry analyser made higher demands due to the need for reagent stabilisation.

4.) Additional considerations

The durability of instruments needed to be considered for our project since we wanted to run the instruments at the highest possible measurement frequency. UV/Vis sondes were favourable due to their robust design. In the case of a wet chemistry analyser, a two year warranty was advantageous as the various hardware components are particularly strained by the high frequency operation.
(vii) No instruments were excluded due to durability or warranty concerns. However the two year warranty on favourable instruments was an advantage (Number 4 and 9).

As a result of our selection process (shown in Table 3) two types of high frequency water quality analysers were chosen. The first was a UV/Vis instrument that claims a higher rating across all criteria, expect for its limitation to a single analyte, and nitrate nitrogen. It compared favourably in terms of high monitoring frequency, low cost, simple maintenance and good durability. This made it suitable for high frequency nitrate monitoring at the sub catchment scale.

A wet chemistry analyser was selected as a second choice of monitoring instrument. It can measure all desired nutrient species across the range of expected concentrations with good accuracy. The maintenance costs were considerable due to field servicing and associated reagent costs. The instrument demanded (i) high quality reagent and standard preparation (as no local reagent vendor was available), (ii) installation of an appropriate instrument housing to moderate the operating environment so that reagent deterioration was minimised during 4 weeks of unattended operation, (iii) field maintenance that included protocols for waste disposal, (iv) the implementation of health and safety plans required for reagent handling and potential hazardous situations (e.g. reagent spills). Despite these drawbacks, it was highly suitable for high frequency nutrient monitoring at the catchment outlet.