Conclusions of the Agricultural Expert Panel

Recommendations to the State Water Resources Control Board pertaining to the Irrigated Lands Regulatory Program

in fulfillment of SBX 2 1 of the California Legislature

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EXECUTIVE SUMMARY

The Agricultural Expert Panel (Panel) was convened to address thirteen questions posed by the State Water Resources Control Board (State Water Board). The questions were primarily technical in nature, and are abbreviated below. The full text of the questions is included in *Section* 2*: Questions for the Panel.*

The Panel's responses deviate significantly from the order and specific content of the original questions. However, the subject matter of each original question is addressed within this report; wherever the subject of a specific question is discussed, a footnote will appear within the text (e.g., the footnote [Q10f] indicates that the text is addressing part "f" of the original Question #10). An index is included at the end of the report to facilitate finding these references.

Questions Posed to the Expert Panel

1. How can risk to or vulnerability of groundwater best be determined in the context of a regulatory program such as the Irrigated Lands Regulatory Program (ILRP)?
2. Evaluate and develop recommendations for the current approaches taken to assessing risk to or vulnerability of groundwater.
3. How can risk to or vulnerability of surface water best be determined in the context of a regulatory program such as the ILRP?
4. Evaluate and develop recommendations for the current approaches taken to assessing risk to or vulnerability of surface water.
5. What management practices are expected to be implemented and under what circumstances for the control of nitrogen?
6. What management practices are recommended for consideration by growers when they are selecting practices to put in place for the control of nitrogen?
7. Evaluate and make recommendations regarding the usage of various nitrogen management and accounting practices.
8. Evaluate and make recommendations regarding the most effective methods for ensuring growers have the knowledge required for effectively implementing recommended management practices.
9. What measurements can be used to verify that the implementations of management practices for nitrogen are as effective as possible?
10. Evaluate and make recommendations regarding the usage of various verification measurements of nitrogen control.
11. Evaluate the relative merits, and make recommendations regarding the usage of, surface water measurement systems derived from either receiving water or a discharge monitoring approach to identify problem discharges.
12. Evaluate and make recommendations on how best to integrate the results of the Nitrogen Tracking and Reporting System Task Force with any above recommendation regarding management practices and verification measures.
13. Evaluate and make recommendations on the reporting requirements to report budgeting and recording of nitrogen application on a management block basis versus reporting aggregated numbers on a nitrate loading risk unit level.

4 RECOMMENDATIONS

The Panel recommends a shift in emphasis in regulatory attempts to reduce nitrate levels in groundwater. The shift would be toward long-term monitoring, source control, and education. The justifications for this shift are:

- Regulations designed to improve or maintain groundwater quality must focus on **source** control for avoidance or minimization of problems – rather than the point-source regulatory approach which depends upon detection of a problem, identification of the individual polluter/owner and discharge point, and enforcement of regulations.
- Because deep percolation of nitrates is universal within irrigated agriculture, a good regulatory program must encompass all irrigated areas, not only lands directly above high nitrate aquifers, those previously identified to be in a high vulnerability area, or those with a certain farm or field size. [Q1] [Q2] [Q2d] [Q3] [Q4d] [Q4][Q4c]
- Nitrate flow to groundwater can best be controlled by avoiding both excessive nitrogen applications and excessive deep percolation. [Q5][Q6] Therefore, the measurement and scheduling of irrigation water depths applied must be included in any realistic source control program.
- There is no simple feedback test that can be applied to nitrogen and water management. Therefore, the development of nitrogen/water management plans for improved source control on individual fields is best done by educated, certified individuals who are able to analyze the local complexities of fertilizer, crops, weather, soils, etc. and who can develop a pragmatic customized water and nitrogen management plan. [Q4b] This is in contrast to a program that relies on farmers checking off a list of Best Management Practices.
- The Panel also understands that high groundwater nitrate levels will not be reduced immediately, and that there is a danger of focusing on areas with high groundwater nitrates or levels of "vulnerability" (as estimated by various indices and methodologies), at the expense of missing potential new problem areas.
- The Panel does not recommend the development of a "scientifically based evaluation of the link between *(a)* proxy metric and actual discharge via a 'Representative practice evaluation'", which appears to be the concept behind the Management Practices Evaluation Program (MPEP) in the Central Valley RWQCB ILRP Orders (found on page 17, Attachment B, Tulare Lake Basin Order R5-2013-0120). Instead, the Panel recommends the use of the A/R ratio, averaged over multiple years after implementation of comprehensive, customized nitrogen/water management plans. [Q9]

The key elements of the recommended regulatory program are:

1. Establishment of coalitions to serve as the intermediate body between farmers and the Regional Boards.
2. Adoption of the A/R ratio as the primary metric for evaluating progress on source control, with eventual impact on the groundwater quality. [Q9]

$$A/R = \frac{\text{Nitrogen } \mathbf{A}\text{pplied}}{(\text{Nitrogen } \mathbf{R}\text{emoved via harvest}) + (\text{Nitrogen sequestered in the permanent wood of perennial crops})}$$

3. Development of a very strong, comprehensive, and sustained educational and outreach program. Such a program will require different materials and presentation techniques for different audiences, such as individuals who may need certification, managers of irrigation/nutrient plans, irrigators, and farmers/managers. [Q8]
4. Creation and implementation of nitrogen/water management plans that are truly plans rather than just a listing of best management practices. These must be customized by features such as crop and locale. [Q5][Q6]
5. Reporting of key values (i.e., crop type, acreage, total nitrogen applied, and total nitrogen removed) by farms to the coalitions. [Q9]
6. Trend monitoring of groundwater nitrate concentrations to track general aquifer conditions over multiple years. [Q9]
7. Targeted research that will directly help the agricultural community to maintain and/or improve yields while simultaneously decreasing the A/R ratio on individual fields.
8. Use of multi-year reported values and monitored trends by the coalitions to inform the agricultural community of progress, to improve understanding of what is reasonable to attain and expect, and to sharpen improvement efforts. [Q9]

These eight recommendations are detailed in the following sections of this chapter.

4.1 Coalitions

The Panel emphasizes that grower coalitions should be strongly encouraged by Regional Water Boards. The Panel recommends strong, local, third-party participation in all regions for the administration of whatever program is put into place.

The Panel finds that the formation of coalitions in Region 5 has been valuable. The Panel recommends their formation in other areas to serve as essential management/operation units. For example, coalitions can collect data from farmers, organize it, and present summaries to the Regional Boards. As local organizations, they can provide strong input to the specifics of their local regulatory programs' formation and modification. They will also serve as the first point of contact in notifying farmers of any apparent compliance problem. The coalitions can also coordinate, sponsor, and/or conduct research and education.

4.2 A/R Ratio

The mechanism of nitrate movement through and beyond the crop root zone is via water flow (irrigation and/or rainfall deep percolation). Therefore, management practices must attempt to minimize water deep percolation, and also match the available nitrogen to the plant needs at appropriate times. [Q5][Q6]

To reduce or maintain nitrate levels in the groundwater, improvements have to start at the surface, which means on-farm. Efforts to improve agricultural nitrogen fertilizer management will be challenging, in part because of common terminology and recommendations that have traditionally been provided to farmers. For example, consider the following statement in an extension publication:

> *Compared to most other vegetable crops, lettuce has a moderate nitrogen requirement, taking up on average only 100 to120 lbs. N/acre. Many replicated trials*

> *have demonstrated that, with efficient water management, seasonal nitrogen application of about 150 lbs./acre should be adequate to achieve high yield and quality; in fields with significant residual concentration of nitrates in the soil even lower nitrogen rates can be adequate*. (Hartz, 2009)

Although there is mention of "significant residual concentration of nitrates in the soil," the recommendation above clearly illustrates two common concepts: [Q5][Q6]

1. Common recommendations are phrased in terms of "requirement" or "demand" and talk about the N uptake from the soil – not the N removal from a field at harvest.
2. Common recommendations have a built-in inefficiency. For example, one could interpret the statement above to say that the plant needs 100 lbs. N/acre, and the recommendation of application is 150 lbs. N/acre – a guaranteed efficiency of 67%, not including the difference between plant uptake and plant N removed.

One important hurdle that must be overcome is that common terminology and recommendations for nitrogen applications that farmers are accustomed to hearing (often related to nitrogen uptake), currently are not consistent in focusing on matching N applications with N removal from fields (the ratio of Nitrogen Applied/Nitrogen Removed). These terms should be defined and emphasized in the training/awareness programs that will be discussed in the next section.

There is also ambiguity when distinguishing between plant uptake of N, and harvested (or removed) N. With some crops, most farmers are very aware of the negatives associated with excess uptake of nitrogen. For example, the yield and quality of cotton and almonds will suffer from excess nitrogen. However, it is difficult to know what the efficiency of N fertilizer uptake is, and information on synchronization is not widely available. Because of this, for other crops (which are not apparently damaged by excessive nitrogen) some farmers commonly apply more N than needed as a sort of "insurance" application to avoid negatively impacting crop quality and yields. The Panel agrees that optimized nitrogen use efficiency should be the focus of management practices encouraged.

Regardless of the difficulties outlined above, the Panel recommends a relatively simple metric to identify progress for this particular regulatory issue. [Q5][Q6]

The metric, to be measured and reported by farmers is the "A/R ratio", where:

$$A/R = \frac{\text{Nitrogen Applied}}{(\text{Nitrogen removed via harvest}) + (\text{Nitrogen sequestered in the permanent wood of perennial crops})}$$

"Nitrogen Applied" includes nitrogen from any source. Example sources are organic amendments, synthetic fertilizer, and irrigation water. [Q4b]

4.3 Effective Educational/Awareness Programs

4.3.1 General [Q8]

The Panel believes that true progress in reducing nitrate leaching will only occur if good irrigation and nitrogen management plans are developed and implemented. The Panel believes that a very aggressive, well-funded, and high-quality educational program is necessary because there simply are not enough qualified consultants and individual farmers to develop and implement good irrigation and nitrogen water management plans.

There are presently a variety of professionals who are trained in irrigation and nitrogen management. Some have academic degrees from pertinent technical university programs in soil science, agricultural engineering, agronomy, or similar subjects. Short courses are offered by universities and commodity groups. Various professional groups have certification programs. The Certified Crop Advisor program focuses on crops and nitrogen, but is weak on irrigation systems and irrigation management. The Certified Agricultural Irrigation Specialist program by The Irrigation Association focuses on drainage, irrigation systems and irrigation management, and salinity, but is weak on crops and nitrogen.

Educational programs must address two key groups:
1. Individual farmers or farm managers who are the water/nitrogen decision makers.
2. Persons who develop the irrigation and nitrogen water management plans

The Panel believes that in many cases, a single individual will fall into both groups. While the level of detail and specific topics to be addressed for each group will be different, several topics are emphasized as critical components of a good grower/farmer education program, including: [Q8a]

- Water and nitrogen needs specific to particular crops – separating uptake versus removal.
- How to create an appropriate irrigation schedule.
- How to implement an appropriate irrigation schedule.
- Irrigation distribution uniformity (DU), and influencing factors.
- Maintenance requirements of different irrigation systems.
- Correct timing of nitrogen applications.
- "Spoon-feeding" of fertilizers and other chemicals, rather than large-dose applications. Currently, most growers have neither the equipment nor adequate education to do this; however, education about and adoption of these techniques should be encouraged.
- Lower-dose, split applications of nitrogen throughout a growing season are highly recommended to reduce N fertilizer applications, if spoon-feeding is not feasible. [Q4b]
- Nitrogen management considerations with crop rotations.
- Fertigation principles – techniques, hardware, and chemicals.
- The standing of other growers in a region. In other words, what is the range of N applications/year for crop "Z"?

4.3.2 Designing the Venue and Materials

Although it is easy to say that education is needed, the "devil is in the details." Funding related to nitrogen has focused on research, to the almost total exclusion of developing strong educational programs for irrigation and nitrogen management either at the university level, or for universities to develop extension materials and programs.

It was beyond the scope of the Panel's task to develop an educational or training program, but the Panel emphasizes that an effective program must address the following: [Q8a]

1. Fill in knowledge gaps and publish them widely.
2. Make a clear decision on what the obligations of individual farmers will be, as well as the justification for those obligations.
3. Define the training venue.
4. Identify target audience(s).
5. Develop standardized training methods, materials, and examinations.
6. Define the certification process for "trainers."

These six steps are described in the next sections.

4.3.2.i Filling in the Gaps

Discussions earlier in this report identified many areas with "unknowns." The Panel acknowledges that many growers lack the information needed to fulfill the requirements of the A/R ratio regulatory program. These knowledge gaps must be identified and the information needed to fill them must be published widely, such as through farming magazines. The primary gaps in knowledge appear to be:

- Harvested (removed) N for various crops.
- Timing of uptake of N for various crops.
- Requirements for various nutrient ratios, to ensure proper N uptake.
- Justification for the difference between UC nitrogen requirement ranges, versus UC recommended application rates that incorporate about a 30% inefficiency.

4.3.2.ii Defining Obligations

In order to gain widespread acceptance of any new program, farmers must be clearly informed of what their individual obligations are, and why. [Q8a] If the obligation is to develop and implement a good but simple management plan, this will be a major advancement for many farmers. The plan, however, must be developed by a qualified individual: either a consultant, employee, or the farmer. [Q8d] The farmer must certify that he/she will adopt the plan and implement it fully within a specified time period or before a specified date. The key elements of each annual plan, for each representative field, could be to: [Q9][Q6]

- Keep records on all nitrogen inputs and timing.
- Keep records on all irrigation inputs (flows and volumes) and timing. This requires a means of measuring or reasonable estimation of the flow rates and volumes into individual fields – **which is a major advancement for most farmers**.
- Keep records of rainfall.
- Have recent measurements of the key components of the distribution uniformity (DU) of the irrigation system, or from a comparable irrigation system on the farm.
- Summarize, in a neat table, the inputs and the expected consumption of water and nitrogen.
- Create a list of improvements to be made the coming year.

4.3.2.iii Defining the Training Venue

If the educational and training programs are expected to be provided for the long term, there must be consistency over many years, with the ability to upgrade and expand training. Several different venues that currently exist or could be created are listed below. An ideal venue may contain various elements from several of the current programs.

1. Certified Crop Advisor Workshops [Q8c][Q8e]

The UCCE recently implemented a workshop effort with Certified Crop Advisors. That workshop appeared to be quite successful because it was very quick and reached a large number of people. However, this type of effort would be difficult to sustain, and difficult to provide long-term with consistency because it consisted of numerous instructors who were given short notice. In addition, there was no testing, so there was no way to objectively evaluate the effectiveness of knowledge transfer.

2. Formal, Multiple-Day Workshops [Q8c]

A possible approach would be to have formal 1-3 day workshops such as those offered at Cal Poly through the ITRC. These are based on structured educational material, and are usually taught by only one or two individuals. Advantages include standardized materials that ensure participants obtain a consistent message from year to year. The timing is published well in advance, so people can plan on these classes every year, and many of the classes dovetail with Irrigation Association certification programs, which require that students pass classes. Such classes would not be for farmers, but would be for advisors/consultants.

3. Distance Learning

Distance learning modules that incorporate testing and accounting of registration, etc. could be developed. With distance learning, people can study on their own schedules, from any location. If the material is standardized, all participants receive the same information from year to year, and the quality of the program does not depend on the instructor. Distance learning can be augmented by written materials, local lab exercises, or could serve as a backbone training tool for an in-person training session. That is, an instructor can be present in Merced, for example, to help stimulate discussion, answer questions, etc. – but the "distance learning module" would be used as the primary teaching tool.

Distance learning also has several disadvantages. For example, a high-quality distance learning package is much more expensive to develop than most people think. It cannot be funded by student registrations, but must be developed with up-front funds. A high-quality course also takes months to develop. It is not comparable to devising a PowerPoint presentation or video-recording a lecture.

4. Standardized Materials Taught Locally [Q8d]

Standardized training materials could also be developed to be presented by local qualified individuals – not necessarily from a university. Some trade associations already do this. Such a program could allow local people to become heavily involved and invested in the program, but it may also be very difficult to get qualified people to teach the courses.

4.3.2.iv Identifying the Target Audience(s)

The training methods and materials must match the target audiences. It is clear that different audiences (for example, Certified Crop Advisors, as compared to irrigation foremen) may have different learning styles and also need to know different levels of detail.

4.3.2.v Standardized Training Materials and Examinations

Once the format(s) is/are defined, standardized training materials must be developed to provide knowledge transfer to those who will develop the irrigation and nitrogen management plans. The State Water Board should approve the curriculum that will be used by various coalitions and groups. If applicable, standardized examinations must also be developed. While the Panel understands that there must always be local customization of training, there is also a common core of knowledge that should be understood.

The core topics must be standardized and well-defined. It will be important to build upon existing knowledge and expertise, rather than start from the beginning. For example, topics might be:

- How to fill out the basic cover sheet for a management plan.
- How to determine timing of nitrogen applications.
- How to determine crop nitrogen requirements, making various assumptions about the nitrogen cycle in the soil.
- How to check for adequacy of nitrogen availability.
- Interaction of N with other nutrients.
- Fertigation principles and equipment.
- Irrigation system evaluation.

4.3.2.vi Certification Process **[Q8b]**

A core element of the Panel's recommended approach is to ensure that decision-makers have a good irrigation and nitrogen management plan that results in good nitrogen efficiency. Unfortunately, there are currently not enough qualified specialists available to develop thorough plans. It takes many years to develop high-quality training materials, implement a full-scale training program, and create more qualified specialists. Such development and execution requires significant funding.

Of key importance is defining the process for certification of "planners." Trainers must be well-qualified. This is a serious challenge. People who understand the plant physiology aspects of water management often mistakenly assume they also know about irrigation system design and management, which is a different topic requiring a different skill set. In a similar vein, "grandfathering" people into certification can be undesirable because years of experience does not necessarily mean that an individual has current knowledge.

A big question is if people need to have degrees in Soil Science or Agronomy. There are likely too few people who have these degrees. Another big question is if people who make management plans should already be certified in some other program.

It is vital to emphasize that simple attendance at classes is insufficient for demonstrating knowledge. Evaluation of course effectiveness is best done by evaluating (through testing) knowledge of the class participants. A simple course evaluation based on subjective statements such as "I learned a little, a lot, or nothing" is not sufficient. Exams need to be standardized, but have a good selection of randomized questions to ensure effective testing of acquired knowledge. Grading must also be standardized. This is a major effort.

No matter what form the certification takes, however, it will be difficult to maintain consistent momentum, year-in, and year-out. Therefore, there must be some official organization to manage any certification program.

4.3.3 Farmer Involvement

The Panel recognizes that if growers (farmers) or farm managers do not attend some meaningful, pragmatic training as described earlier, the desired goal of reducing nitrate leaching will not be met. It was the consensus of the Panel members that compliance will be low unless there is some enforceable requirement. The Panel members struggled with defining the proper incentives for grower compliance with management plan and training requirements. A variety of ideas were discussed, without a final decision for a recommendation. [Q8a]

One of the stronger ideas presented was that nitrogen fertilizer sales should be handled the same way as pesticide sales, in the sense that pesticides can only be sold to a purchaser who has a valid and current permit. There are testing and continuing education requirements to obtain and maintain the permit. The permit is issued and recorded by the county Agricultural Commissioner, and must be on file with the pesticide seller. In a similar fashion, nitrogen fertilizers could be sold only on the condition that farms have on record, at the fertilizer sales office, a form that certifies the completion of a satisfactory irrigation water and nitrogen management plan. [Q4b]

The Panel recognizes that there will likely be challenges in getting widespread compliance from growers with small farms. There is likely a need for special training, funding, and/or reporting requirements for this group.

4.3.4 Other Details

The Panel acknowledges that there are liability concerns by some specialists who might eventually develop management plans. The State and Regional Water Boards must clearly define that the developer of plans will not be responsible for the proper implementation of that plan unless that person is also the implementer. Furthermore, it must be stated that it is understood that plans will be imperfect, and will be modified/upgraded over time after re-assessment of results, and as knowledge improves.

Three important issues that were discussed, but not finalized, were:
1. The timeline for the various components of the educational effort.
2. Requirements for continuing education.
3. Who will review whether management plans are implemented.

4.4 Nitrogen Management Plans [Q7d]

The Panel has chosen not to create a "laundry list" of Best Management Practice (BMP) options for growers. Such lists[7] already exist, but generally lack sufficient detail to be effective on a site-by-site basis, and usually do not address the root of the problem. The Panel agrees that lists of any specific practices should be in the form of heightened awareness only, rather than requirements.

Instead, the Panel believes that future efforts should focus on the following four areas:

1. **Creation of irrigation and nitrogen management plans specific to each grower and similar management unit**
2. Development and execution of awareness/education programs (discussed in *Section 4.3: Effective Educational/Awareness Program*).
3. Implementation of the management plans.
4. Internal (on-farm) review and assessment of the impacts (crop quality, amount of fertilizer and water used, gross costs). [Q4b]

4.4.1 Collecting Pertinent Data [Q7d]

A first step (possibly requiring 1-3 years) for many management plans will be to describe and develop the data collection process (water and fertilizer) [Q4b], and data organization procedures and tools to accomplish this. The management plans will be subject to audit. Therefore, the data must be organized so that they can be easily understood by an auditor. The Panel recommends that the coalitions define the format of the data (database, tabular, spreadsheet, etc.), and the content.

The details of these plans should be used for management only, and not for reporting purposes to the RWQCBs. The management plans should aid growers in determining the current status of their nitrogen use, as well as developing tools and practices to optimize nitrogen applications. To begin the creation of a management plan, the irrigation/fertilizer decision makers must be knowledgeable about certain data (which should be updated at least annually). These data include: [Q5][Q6]

- How much nitrogen is being applied from all sources, including fertilizers, compost, irrigation water etc., plus residual nitrogen, as well as the timing and uniformity of the applications. [Q4b]
- Residual nitrogen in the soil.
- How much nitrogen is removed, by crop type. The Panel considers "N removal from fields" to include both the harvested portion and the nitrogen that is used for growth expansion on perennials (e.g., a number of 25 pounds/year/acre has been quoted for almond trees).
- The volume of water applied to a field (minus recovered tailwater for surface irrigated fields).

A subsequent step should be the organization of the prior year's irrigation and nitrogen application schedules and amounts, combined with determination of how those could be improved.

[7] For examples, see the NRCS's Nutrient & Pest Management program (www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/crops/npm/), or the Best Management Practices Studies compiled by the Coalition for Urban/Rural Environmental Stewardship (CURES) (http://www.curesworks.org/bmp/bmpGeneral.asp)

4.4.2 Creating the Plan [Q5][Q6] [Q7d]

From the collected data, an appropriate nitrogen management plan, an appropriate irrigation schedule, and a plan for irrigation system maintenance should be developed for the upcoming year/season based on system type and anticipated crop demand.

The Panel emphasizes the following points about the proposed nitrogen management plans:

- Having a well-designed and implemented irrigation water and nitrogen management plan is a fundamental and good farming practice. [Q7d] The Panel believes that the management plans must be individualized and developed by competent individuals, and that the plans must identify actions to be taken to improve performance.
- The Panel believes that the State and Regional Water Boards should agree on the qualifications of the individuals who will create and evaluate irrigation and nitrogen management plans and the requirements of these plans. It is recommended that individual plans will not require approval from the Water Boards, but must be available for Water Board staff review.
- All management plans must include estimates of nitrogen required, nitrogen removed, the volume of water infiltrated in a field (separated as rainfall and irrigation), and the ET of the crop. They must account for the fact that some of the variables change over the season.

A management plan will describe processes, procedures, and/or objectives that are applicable throughout each management unit/farm. For example, items such as wellhead protection, installation of new fertigation equipment, and checking distribution uniformity of systems will fall in this category. The Panel acknowledges that describing and understanding the nitrogen management of a 160-acre almond orchard is relatively simple as compared to describing and understanding the nitrogen management of sixteen 10-acre produce crop fields. While it is recommended that the same information be recorded for both situations, it is clear that requiring separate management plans for individual fields – often of an acre or less with produce crops – is unreasonable.

Within the management plan more detail will be provided for individual reporting units. The plan for individual reporting units will include an estimated fertilizer application schedule (amounts, timing), irrigation schedule (amounts, timing), and irrigation maintenance program. It will also define what/how data will be collected to estimate nitrogen and water application requirements. The process to annually evaluate the effectiveness of the plan should be described; this should focus on basic indicators such as the N applied versus removed.

4.5 Data Collection for Reporting Purposes

The Panel's recommended regulatory program includes the reporting of certain data. The Panel also assumes that these same data may have value to farmers in reducing fertilizer and/or water costs, and possibly improvements in yield. However, the data must be collected properly to have value. [Q9]

Some Regional Water Board testimony distinguished between data that needs to be collected, versus data that needed to be reported, versus data that needed to be maintained on-site for

inspection by a farmer. Some speakers seemed to imply that as long as data were not reported, the cost to obtain that data would be small. The Panel believes that the cost and time of data collection for a farmer is similar whether it must be reported or not.

The Panel also acknowledges that much data that could be useful is often either not easily attainable, or simply unknown. For example, applied water volumes to individual fields are not known in many cases with a high degree of accuracy. Many irrigation districts in California are currently struggling to meet a +/- 12% accuracy standard for measurement of annual volumes at district turnouts. Once district water is beyond the turnout, it is often split, applied to a large number of fields, mixed with groundwater in common pipe systems, and is generally not measured to individual fields.

Therefore, the Panel is proposing a data collection effort that is simple, yet effective.

4.5.1 Purpose of Data Collection

The Panel emphasizes that reporting by growers and any data collection requirements should be coordinated by third-party coalitions where feasible, rather than having farmers report directly to the Regional Water Boards. Coalitions should be allowed to define protocols for sampling of key quantities such as harvested nitrogen.

The Panel clearly recommends that the data collected be used for education and later development of management plans, not initially for enforcement. Grower understanding and improvements are critical in the effort to reduce nitrate losses to groundwater, and growers will be reluctant to participate in programs if they risk self-incrimination. In particular, current groundwater conditions in a region or below a farm should not be considered by Regional Boards to administer different levels of on-farm data collection and/or reporting requirements. Instead, current groundwater conditions can be useful for grower awareness by providing:

- Awareness of key components of on-farm nitrogen management about which he/she must be knowledgeable.
- Knowledge of whether his/her farm is in an area that has high nitrates in the groundwater.
- Knowledge of the level of nitrates in the groundwater that he/she is using as his/her irrigation water.

The basic data collection effort proposed by the Panel provides several compelling benefits to farmers, the ILRP, and groundwater quality in the long term. [Q9] It gets to the root of the nitrate issue in a simple, timely, and attainable fashion. This data collection effort serves two main purposes:

1. Development of baseline nitrogen application information, crop-specific, and integrated regionally. This provides the basis for comparison of regional nitrogen application differences and addresses the probability of nitrogen leaving the crop root zone via deep percolation. [Q10f]
2. Identification of multi-year trends as the data collection is continued.

4.5.2 Reporting

4.5.2.i What Data Should be Collected for Reporting

Any improvements in nitrogen management on the ground must require the development and implementation of simple and pragmatic nitrogen and water management plans by farmers. A key element of any field/farm nitrogen management program is a record of the nitrogen applied to fields. [Q7a]

The recommended data collection/reporting effort seeks basic information, aggregated over the course of one year (e.g., calendar year or crop year), on a reporting unit scale. This effort purposefully limits data collection to basic information that can be easily obtained and all farmers need and should be knowledgeable of as part of their nitrogen management. The data collected should be:

1. Location of the reporting unit.
2. Crop (e.g., lettuce, wheat, almond).
3. Nitrogen removed by harvest or sequestered in permanent wood.
4. Crop acreage (acres) – The crop acreage is the total acreage on which a specific crop is grown. If three different crops are grown in succession on the same field, this field's acreage is used to compute the nitrogen inputs for each of the three different crops. Nitrogen inputs to multiple plantings of the same crop are aggregated over the year.
5. Nitrogen applications for each crop (lbs./acre) including organic applications (e.g., manure, compost), synthetic fertilizer applications, and nitrogen in irrigation water [Q4b]. This requires separate estimation and documentation of these three nitrogen sources. The nitrogen application computation should include the total nitrogen applied as:
    - Organic applications (manure, etc.)
    - Synthetic fertilizer applications
    - Irrigation water

The Panel acknowledges that this method (reporting applied N) is imperfect. For example, a crop planted after alfalfa is removed will have a smaller nitrogen requirement than one that does not follow a legume. Nitrogen requirements will depend upon many factors. As stated earlier, multiple years and multiple fields will create an averaging effect.

The Nitrogen Tracking & Reporting System Task Force (NTRSTF) provided a Final Report in December 2013 that listed recommendations for reporting. [Q12] Their list and this Panel's list are short. The NTRSTF recommends a reporting of annual residual soil nitrogen credits. The Panel does not include residual nitrogen in its reporting recommendations because it is difficult to quantify and is subject to potentially large short-term fluctuations. The multi-year approach of this Panel in effect minimizes the value of residual nitrogen for reporting purposes.

4.5.2.ii Reporting Units

The Panel recommends that the "reporting unit" be defined in one of two ways: (i) on a crop basis, which could include multiple fields that have similar soils, irrigation methods, irrigation water nitrate levels (not defined by the Panel), and irrigation/nitrogen management styles; alternatively, (ii) a reporting unit could be defined as an individual field. The Panel's

recommendation for grouping of multiple fields is more restrictive that the "nitrate loading risk unit" [Q2b] [Q13], or "management block" defined by Region 3.

The recommended reporting unit provides the flexibility to farmers to group fields in a customized manner so that it makes operational sense in part because multiple fields may receive nitrogen applications simultaneously but without the infrastructural means to separate their applications. It gives the flexibility to vary the field sizes between crops and seasons. It does not necessitate mapping or farm-scale spatial analysis.

4.5.2.iii Possible Grower Concerns

The Panel understands that details about the blends of fertilizer and the timing of fertilizer applications are considered to be the same as a trade secret by most farmers. Details of this type do not need to be shared for any reasonable nitrogen management reporting program.

It was discussed whether a program that requires reporting nitrogen concentration in groundwater might provide a disincentive for farmers to use high-nitrate water. The Panel members believe that there should be no disincentive to pump high-nitrate water, and coalitions and Regional Water Boards must be especially careful to finesse guidelines that emphasis this point.

4.5.3 Data Consolidation

The time period for a report should encompass a 12-month period, and should consolidate monthly or short-season values into single reported values. However, it is recommended that this annual data be evaluated on a multi-year basis. It is emphasized that the collected data should be used to examine regional, multiple-year conditions and trends of nitrogen applications. Analysis of these data on too-short time frames (e.g., year-to-year) will introduce random error and potentially misleading results because many confounding variables, such as residual soil nitrogen and nitrogen removal rates, vary by year and by crop rotation. These differences tend to even out over multiple years. It is also emphasized that the data should not be used for regulatory enforcement because the possibility of regulatory consequences will compromise the accuracy of the data.

The Panel strongly recommends not assigning a regulatory value to the A/R ratio on an annual basis. Such ratios have merit for categorizing fertilizer management using multi-year averages. The Panel also emphasizes that the A/R ratios are not known at this time, that farmers, extension agents, and crop advisors need time to learn about these ratios, and we do not yet know the ranges of these values by region or by crop. Therefore, it is strongly recommended that such ratios not be used for regulatory action at this time.

4.6 Monitoring

The points below define the conceptual framework for an effective program that includes regulation, verification, and positive results. [Q9]

4.6.1 Farmer/Coalition Components

Farmers must be required to develop and implement good irrigation and nitrogen management plans (described previously). [Q7d] This recommendation comes with the caveat that certain groups (such as the rice growers on clay soils) may be considered for exemption because of very unique chemical situations, and that the groundwater quality of some areas may be de-designated from beneficial uses related to drinking water. This Panel asserts that a good irrigation plan, which requires measurement of volumes of water and the development of reasonable irrigation schedules, belongs in the program. The only way nitrates can move below the root zone is via deep percolated water.

The Panel recommends that reporting by farmers to the coalitions should be required, and be simple yet effective. The basic elements of reporting are reporting unit location, total nitrogen applied, estimate of nitrogen removed from the field by the identified crop, and acreage. Because of nitrogen transformations, and stored water and nitrogen (in the root zone), reporting should contain annual (or crop cycle) values rather than more frequent data. Multiple years of data (minimum of 3 years) are likely needed to ascertain trends and patterns. [Q9]

Irrigation water and rainfall volumes are not required for reporting, because the impact of good water management is evidenced by the nitrogen applied versus removal ratio. Those volumes are essential elements of an irrigation and nitrogen management plan, however. Individual fields can be grouped into units for reporting purposes, in which all fields have the same crop (or very similar crops as designated by coalitions; this is primarily targeted toward produce crops), same irrigation and nitrogen management plan, same irrigation water quality, same irrigation method, similar soils and same general geographic area.

4.6.2 Regional Groundwater Trend Monitoring

The monitoring of first-encountered groundwater is problematic, expensive, inconclusive, and in general would require a diversion of resources from important source control efforts. [Q10a] There are also serious limitations to drawing conclusions from single-year monitoring values. Such trends will not be useful for correlating the impacts of specific field practices on individual fields to underlying aquifer water quality.

Long-term monitoring of groundwater nitrate concentrations at strategically selected points throughout regional aquifer systems is important in the assessment of the long-term effectiveness of the regulatory efforts. Much thought should be given to the exact extent of such monitoring efforts. Existing and new data collection efforts should be coordinated to ensure an effective overall program without unnecessary duplication of efforts. The long-term monitoring effort should be objective-oriented and the ultimate scope of the effort (e.g., number and geographical distribution of wells, rationale for selection of individual wells, sampling protocol, data quality objectives, sampling frequency, list of constituents, and degree of integration of data collected by other entities) should be evaluated as to its ability

to achieve these objectives. Multi-year values are necessary to smooth out the random fluctuations that occur on an annual basis. They also allow for the use of simplifying assumptions regarding changes in nitrogen pools within the root zone. [Q9]

4.7 Targeted Research

Pragmatic research is needed to identify attainable ratios for a range of crops and situations. Some of this research will be done by coalitions as they examine the reported data. Other research will be more traditional and will be related to topics such as rates and timing of nitrogen uptake and crop removal. The Panel also believes that research must be conducted to define sampling intervals, sampling density, and other factors. [Q10d]

4.8 Verification

The Panel recognizes that the State and Regional Water Boards must have some way of measuring progress over time on a regional basis. However, deep groundwater nitrate levels, examined over periods of less than 10-20 years, cannot be expected to demonstrate such an impact. A different metric must be used. [Q9]

Many factors, such as residual nitrogen and nitrogen removal rates, vary by year and by crop rotation. These differences tend to even out over multiple years. In collecting initial data, the Regional Water Boards will be able to report to the State Water Board a specific multi-year baseline for future comparison. This baseline can be used to indicate progress in the long term. Similarly, when viewed on a regional basis, areas with a relatively high nitrogen use can be easily identified based on this data. [Q9]

The Panel agrees that the trend monitoring of groundwater nitrate concentrations (not first-encountered groundwater) should occur, in order to track general aquifer conditions over multiple years. [Q10a] This can be done with water samples from existing wells. [Q9] *Section 4.6.2: Regional Groundwater Trend Monitoring* discusses how the data collection for trend monitoring should be defined. The Panel did not attempt to define all of the details of a monitoring program.

The metric recommended by the Panel is the long-term trend of the relationship (A/R) between nitrogen applied and nitrogen removed from the field, using information reported by farmers to the coalitions. Verification will consist of knowing if the A/R is reduced. [Q9]

4.9 Surface Water Discharges

Monitoring the water quality of surface discharges from individual fields/farms, as a general policy, has the following problems: [Q3] [Q4] [Q10e] [Q11]

1. Water quality tests are quite expensive, even with individual samples.
2. Periodic sampling of water runoff as opposed to extensive sampling has serious challenges with being able to identify events that might cause pollution of streams, because: [Q10d][Q10d]
    a. The timing of individual sample collection might not coincide with pesticide applications, or with events of high sediment runoff.
    b. It is difficult to identify, in advance, exactly when (time of day and day) there might be surface runoff. This is because irrigation schedules constantly change as field crews shift operations.

   c. Typical labor schedules for samplers require that samples be collected during daylight hours, from M-F. Other times/days may be more important.
   d. The schedule of lab operations, and constraints of sample hold times, may not coincide with irregular timing of surface discharges.
3. Continuous water sampling equipment (to collect samples, and in some cases to also analyze samples) is available for some constituents, but it is very expensive, complicated, and subject to vandalism.

With surface water discharge monitoring, there is a special appeal for some type of coalition effort because it meets the recommendation of the Panel on how to address monitoring. If individuals do not belong to a coalition, there does not seem to be any alternative to expensive sampling of every discharge point.

For surface water issues, the Panel recommends water quality monitoring of receiving water and a clear understanding of the watershed hydrology. Sufficient samples should be taken in the watershed streams to detect if problems do indeed exist. The sampling should be of sufficient density (spatially and temporally) to identify general locations of possible pollution. This is recommended rather than sampling at each discharge point. For example, a single measurement point at the downstream discharge of a very large watershed would be insufficient. When/if problems are identified, sampling should move upstream to locate the source of the problem.

Individual point discharge measurements/monitoring would be used only if individual points are identified as being serious contributors to water quality problems, based on samples taken upstream in the watershed.

Recommendations of the exact density and timing of sampling are not provided by the Panel, because the details will depend upon the size and complexity of the watershed, and upon the results of data that are collected. If, for example, an initial and sparse network of sampling points at watershed bifurcation points indicates that there are no problems, it would be unreasonable to require a more intensive sampling point network.