CONCLUSION

The popular view of technological decision-making as a process in which decisions are made by experts using technical data[1] is not supported by the case study of the development of Sydney's sewerage system. Clearly, experts are not the only ones involved in the decision-making process and 'technical factors' are only part of a range of considerations. In addition it has been repeatedly shown that the term 'technical factors' is misleading since so-called technical issues and criteria of technical evaluation are themselves constructions. This study has clearly shown that an interactive and constructivist model of technological development is far more appropriate than a linear objectivist model because of the interweaving of social, political, economic and technical factors in the decision making process from the first conception of a technological project through to its implementation and operation.

Sydney's sewerage system was conceived within a social context which shaped its physical form. It was not constructed simply to improve the public health of those who lived in insanitary conditions. The push for sewers came from professional groups, bureaucrats and middle class people who were concerned about the economic and moral costs of dirt and disease, as well as the health risks to themselves. Heavily influenced by what was happening in Britain, the newspapers emphasised an association between sewage and drunkenness, prostitution, crime and vice. City slums became the focus of fears about radical political movements and revolution. The economic costs of lowered productivity from ill-health, charity to families made into paupers by the death of working parents, unpaid rents and vandalism were weighed against the heavy cost of sewers in a new city and the necessary increases in rates, which ratepayers were ever reluctant to pay. The advantages of government control and the imposition of order on the masses were balanced against *laissez-faire* principles of minimal government intervention popular at the time.

The argument for control and order reigned supreme in the end and the government took over responsibility for managing the city's waste products. The choice of technologies for this task was heavily influenced by the objectives set in the previous public debate over sanitary reform. Sewers were far more amenable to public control than dry conservancy schemes and achieved the goal of rapid and automatic removal of wastes from homes.

COMPETING TECHNOLOGIES AND THE PROBLEM OF CLOSURE OF DEBATE

The debate between water-carriage technology and dry conservancy methods is an example of competing technologies where artifacts were perceived differently by different social groups and therefore exhibited an "interpretative flexibility" as described by Pinch & Bijker.[2] It was the interpretation of water-carriage technology as modern, healthy and problem free which triumphed over an

[1] Ronald N.Giere, 'Controversies Involving Science and Technology: A Theoretical Perspective', in H.Tristram Engelhardt, Jr & Arthur L.Caplan, eds, Scientific Controversies, Cambridge University Press, 1987, P142.

[2] Wiebe Bijker & Trevor Pinch, 'The social construction of facts and artifacts: or how the sociology of science and sociology of technology might benefit each other', Social Studies of Science 14, 1984, pp 399-441.

alternative interpretation of water-carriage as polluting, unhealthy and wasteful of natural resources. Engineers also preferred water carriage technology which involved large scale excavation and construction of sewers as well as the centralization of sewage for disposal.

The dry conservancy enthusiasts were concerned that the nutrients in sewage be utilized to fertilise the land rather than pollute the waterways. This could be done more effectively if the wastes were not diluted in water and transported to a centralized point for disposal but were rather retained in their pure or in an improved form that could be more easily taken to where manure was most needed.

Some authors, including Pinch & Bijker, have sought to understand the choice of technology through understanding the different interpretations that various social groups attached to an artifact and the enrolment of opposing social groups by rhetoric and problem redefinition. In this case the closure of the debate cannot be so simply explained. The different value system which the dry conservancy advocates adhered to was not compatible with that of the water carriage advocates and closure never really occurred as far as they were concerned. The desire for utilisation of sewage remains strong in sections of the population more than one hundred years later despite the supposed closure of the debate by those in power. For many people the debate goes on today. Their approval or enrollment was, however, unnecessary to the implementation of water carriage technology.

The problem is that the power relationship is underplayed in many analyses of technological choice and this can lead to erroneous perceptions. Although the implementation of water carriage technology in Sydney was accompanied by rhetoric and attempts to enroll the public and redefine the problem, these do not seem to have been decisive in the final outcome. In fact these tactics were used by people advocating water carriage and people advocating dry conservancy. Similarly both sides were able to put forward experts and give statistics and figures to support their favourite schemes.

Timing was a significant factor in this dispute. Dry conservancy methods did not reach their peak of popularity until many sewerage systems had been constructed. Their popularity was a result, in fact, of the pollution of waterways that was perceived to accompany water-carriage methods. This lateness on the scene was an immediate drawback since sewers had been installed and had proven statistically to achieve immediate results in decreasing the mortality rate in areas where they were installed. Moreover, the existence of a physical infrastructure of pipes encouraged the continued use of pipes rather than the scrapping of an expensive and proven system in favour of a relatively unproven one.

Although Pinch and Bijker concentrate on varying interpretations of artifacts in terms of problems associated with them, artifacts can also be interpreted in terms of the opportunities which the artifact offers for control or power. This interpretation of an artifact may well be hidden behind rhetorical interpretations which are expressed. The government and public service engineers preferred a system that could be controlled and that was compatible with a centralised government bureaucracy staffed by experts. Water carriage brought sewage disposal within the engineering domain and gave them professional control over the field. Engineers also saw an opportunity to establish themselves as experts in the new field of sanitary engineering and to increase their role in city management.

The coalition of politicians, public officials and engineers was a powerful one. The debate which took place in the newspapers was peripheral and those with power did not bother to take part in it. Engineering reports and texts touched on alternatives to water-carriage in a dutiful but cursory manner in a token of respect for the notion of a pluralist, democratic society that allowed all voices to be heard. The engineers continued to design water-carriage schemes and the government continued to fund them. By the end of the century sewers were so clearly entrenched that the word "sewerage" had come to define human waste products.

Tristran Engelhardt and Arthur Caplan have nominated five categories of closure in scientific controversies by amalgamating those put forward by Tom Beauchamp and Ernan McMullin. The first is "closure through loss of interest" which corresponds to Beauchamp's "natural death closure" and McMullin's "abandonment".[3] This type of closure implies that a controversy ends because participants lose interest. No resolution or concensus has been reached but the issue has lost its importance or is no longer the focus of interest or controversy.[4]

A second category of closure is "closure through force". The controversy is ended although there is no rational basis for resolution. This may occur when an external authority declares a decision, or by the use of state power, or even the loss of funding.[5] Everett Mendelsohn also pointed out that closure is sometimes achieved when those who are weaker in political strength can be driven from the scene and, although they still maintain their position, they are unable to continue the open confrontation.[6]

These authors were dealing with scientific controversy but their analysis is relevant to technological controversy as well. In the case of the debate over sewage collection methods both these means of closure have occurred. A decision was imposed through the power of the state by the construction of sewers and the diversion of sewage from the harbour to Bondi and thereafter debate died. Dry conservancy methods lost their popular appeal because they were no longer seen to be attainable, but also because sewage farming seemed to offer an alternative way of utilising sewage.

The choice between sewage farms and ocean outfalls was very similar to that between water carriage and dry conservancy technology. Again the different objectives, utilisation of sewage or quick and easily controlled disposal, were involved. Sydney's sewage farm was seen by those in power as a short-term

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3 H.Tristram Engelhardt, Jr & Arthur Caplan, 'Patterns of Controversy and Closure: the Interplay of Knowledge, Values, and Political Forces' in Engelhardt & Caplan, Scientific Controversies, pp1-26.

4 Tom L Beauchamp, 'Ethical Theory and the Problem of Closure', in Engelhardt & Caplan, Scientific Controversies, p32.

5 Ernan McMullin, 'Scientific Controversy and its Termination' in Engelhardt & Caplan, Scientific Controversies, p78.

6 Everett Mendelsohn, 'Political Anatomy of Controversy in the Sciences' in Engelhardt & Caplan, Scientific Controversies, p101.

measure which would satisfy the public's desire for sewage utilization. It was argued that should the sewage farm be unsuccessful, the public would then readily accept the preferred option of the engineers and public officials. In this way the opposition could be enrolled. Their interpretation of water-carriage as wasteful needed expression before that enrollment could take place.

Nonetheless the sewage farm was also the cheapest option in the short-term and the infrastructure needed could mostly be used for the preferred scheme which it was envisaged would later be implemented. Had the sewage farm been uneconomical and inconvenient, the authorities would almost certainly have been less ready to go to such lengths to enrol the opposition. Nonetheless the sewage farm experiment was unsuccessful in achieving enrollment and closure in the long term. In a very real sense this debate goes on today and closure has never occurred and this fits McMullin's observation that the original disagreement still persists to some extent when closure is forced.[7]

The solidarity of the engineers on the issue of ocean outfalls was increasingly supported by evidence of failed land-based treatment experiments that had been poorly sited and quickly overloaded because of long term plans for ocean disposal. Moreover, as the years went by, a momentum was built up of a sewerage system directed towards the sea with a growing infrastructure and capital investment. In this way past decisions shaped later ones and all that concerted protest was able to achieve was diversions from one polluted spot to another. The power of the coalition of engineers and bureaucrats was cemented in the form of pipes and pumping stations.

PARADIGMS, SYSTEMS AND THE PROBLEM OF CHANGE

The three other categories of closure that Engelhardt & Caplan outlined are more relevant to scientific and technical communities; "Closure through sound argument", "closure through negotiation" and "closure through consensus". The two latter depend on social processes that occur between participants.[8] Beauchamp observes of consensus closure,

> Here it does not matter whether a correct or fair position has been reached. It does not matter whether, as a matter of justification and method, some point of view is well defended. Nor need principals believe that a permanent solution has been found, or even a definitive one. It only matters that there is consensus agreement that the force of one position has overwhelmed others. . . the weight of evidence might play no role at all in bringing about the consensus.[9]

The authority and control of engineers as experts in the field of sewerage management was assured through closure by consensus following the British Royal Commission into Sewage Disposal. The debates between engineers over sewage treatment technologies required a different form of closure from that which operated in the public arena because the relationships between opposing sides were different. Consensus occurred after the Royal Commission

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[7] McMullin, 'Scientific Controversy and its Termination', p79.

[8] Engelhardt & Caplan, 'Patterns of Controversy and Closure', pp14-15.

[9] Beauchamp, 'Ethical Theory and the Problem of Closure', p30.

recommended standards of effluent to be met and put an end to the search for ever better treatment methods. The Commission, with its prestige and influence, was able to define evaluative criteria that enabled sewerage engineers to work out an agreed paradigm of practice.

For many decades engineers have chosen sewage treatment solutions from a small range of technologies that are consistent with the water-carriage of sewage (in pipes) to a point adjacent to a waterway where the sewage effluent will be discharged. Alternative technologies which are decentralized, land intensive or based on utilization of sewage products have been ignored. The paradigm relied on dilution and gravity as primary mechanisms for dealing with sewage. It incorporated a philosophy of staged treatment, whereby treatment was to be installed stage by stage so that at any one time only a minimum amount of treatment would be installed. As public complaints and political pressure increased, then a bit more treatment would be done. This delayed the agony of public spending.

Engineers minimise their designs as part of an inbuilt engineering philosophy but the incorporation, in engineering design, of economic priorities that enable engineering projects to be built with a minimum of materials, labour and capital and so ensure profits are maximised may be misplaced in this sort of application where other goals are supposed to be paramount. In other fields of technological development the search for reduced costs can promote technological innovation but in the field of sewerage engineering the temptation is to reduce costs by reducing efficiency rather than by innovating.

In its own way the philosophy of staged treatment was a recognition by engineers that the "efficacy" of treatment methods was socially constructed and therefore variable and they were making provision for changing public perceptions of what was "good enough". The skill of the engineer lay in being able to choose a minimum form of treatment from the paradigm and convincing the public that this was all they required.

Sedimentation came to dominate as a primary treatment. Although chemical precipitation was more effective at removing suspended solids and sedimentation was no cheaper when full treatment was considered, sedimentation was adequate as a treatment when combined with a secondary biological treatment to satisfy the standards recommended by the Royal Commission for disposal to rivers and it was cheapest as a single stage treatment. Therefore sedimentation became the accepted primary treatment although it was also used without further treatment for ocean disposal. More recently the Sydney Water Board together with its consultants have come up with a way of reducing primary treatment even further as part of the continual engineering quest for minimising treatment technologies.

Because of staged treatment, sewerage technology exhibits what has been referred to by some writers[10] as a 'trajectory' which is particularly persistent. The trajectory projects into the future the socially constructed characteristics of the system acquired in the past when the physical

[10] Giovanni Dosi, 'Technological paradigms and technological trajectories', Research Policy 11, 1982, pp147-162; Richard Nelson & Sidney Winter, 'In search of useful theory of innovation', Research Policy 6, 1977, pp56-60.

components were designed.[11] At present Sydney's sewerage system has a physical and figurative trajectory out to sea. Nelson and Winter also suggest there are more general trajectories common to a wide range of technologies. Two which they mention are latent scale economies and increasing mechanisation of operations.[12] Both of these can be observed in Sydney's sewerage system.

The general trajectory of mechanisation or automation was noted earlier in this chapter to have influenced the choice of water-carriage technology. The increasing centralisation of Sydney's sewerage, which has been perceived to be the cheapest option not directly because of economies of scale but because it has always been cheaper in the short term to use the existing facilities. This has caused massive overloading of the three main sewage treatment plants in Sydney, a resultant sewage flow which is too large and too heterogeneous to be able to treat properly and the discharge of raw sewage into all of Sydney's waterways through sewage overflows every time it rains heavily.

The engineering paradigm has played a key part in the larger technological system, which includes legislation, bureaucracies, industrial interests, health authorities etc. The commitment of both organisations and their experts to existing systems can also be found in other social groups such as educational institutions and manufacturing companies. Moreover vested interests are compounded by fixed assets and sunk costs. All these factors add to the momentum which a system accumulates.

The sewerage system in Sydney, like other systems, has grown to have its own considerable momentum. The Metropolitan Water Sewerage & Drainage Board is a very large organization dedicated to the system and its engineers are skilled in the sewage collection, treatment and disposal methods that have been in use most of this century in Sydney. The relevant professional associations support current sewerage engineering practice. Australian universities teach these methods and radical alternative methods are not researched either in government or private industry, except where firms outside the system can see some profitable use can be made of their own products and skills. (for example CIG and its in-sewer oxygen treatment).

Moreover the fixed assets and sunk costs, the physical infrastructure is a powerful conservative force. Because engineering practice incorporates cost minimisation, engineers are always keen to make use of whatever is available to them in terms of natural and 'man-made' resources in their efforts to minimize costs. There is a great reluctance to tear down existing treatment plants and start again. An old treatment plant will have involved a large capital input when it was first built and will probably be achieving some results, even if those results are unsatisfactory. Even if new methods were developed engineers would in most cases prefer to improve or upgrade or augment the existing facility.

The role of engineers in the technological system has been a decisive one. The autonomy of the engineering community lies in its ability to dictate the range

[11] Thomas Hughes, Networks of Power: Electrification in Western Society, 1880-1930. John Hopkins University Press, 1983, p140.

[12] Nelson & Winter, 'In search of useful theory of innovation', p58.

of technologies which will be taken seriously. Outside authorities may set standards and regulate the available money but the engineers decide how to meet the standards and if they can be met with the finances available. The community may demand a higher level of treatment but they would have great difficulty in getting alternative treatments from outside of the paradigm accepted.

The dependence of standards on concepts of "best practicable technology" also gives a great deal of autonomy to the engineering profession in determining appropriate technology and thereby supports the existing paradigm. Moreover, measures of efficacy and evaluative criteria are largely shaped by engineers, both overseas and in the major sewerage authorities in Australia. On top of this the Sydney Water Board has a great deal of power and political influence because of alliances with other polluting organisations and because of the dependence of the SPCC on the Board's acceptance of industrial waste to protect more sensitive parts of the environment.

Engineers are clearly powerful when aligned with powerful organisations. They are nevertheless employees and subordinate in every sense of that word; dependent on their employers for continued employment and promotion. Whilst they are loyal they are rewarded and given influence, and their commitment to the technological system is assured. In return they remain anonymous and must pass their technical advice upwards, in confidentiality, "to separate decision makers, foregoing any explicit rights in policy making".[13]

However, engineers are able to implicitly influence policies through the advice they give. They have the ability to manipulate non-engineers through their construction of engineering knowledge. As much of the work in the social studies of science has shown, scientific knowledge embodies social objectives, values and ideologies. Similarly, and perhaps even more so, engineering knowledge is shaped by social choices as to what data should be collected and how the results should be interpreted. Sewerage engineers have from the beginning purposely put together studies with end purposes in mind, being careful to gather only information that helped to promote their projects and justify them. In recent years, using computer models and complex scientific-like investigations, they have been able to put together a knowledge base that lay people find difficult to challenge. Where, in the case of the Sydney Water Board, policy makers are politicians or Board members, who are not appointed for their ability to understand engineering knowledge, engineers are able to control the options that are considered and present their preferred option as the most favourable.

The sewerage engineering paradigm and accompanying knowledge base not only allow engineers to make overly optimistic predictions about whether their projects will "work", but they are able to manipulate the definition of the term to support their later claims that they do "work" once they are built. The "testability tradition" which Edward Constant has referred to[14] in the case of sewage disposal is based on suspended solids, biological oxygen demand and more recently faecal coliform levels but these do not take account of more

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[13] Barry Barnes, About Science, Basil Blackwell, 1985, p100.

[14] Edward Constant, 'Scientific theory and technological testability: science, dynometers, and water turbines in the 19th century', Technology and Culture 24(2), April, 1983; 183-198.

recent developments in scientific knowledge or more recent dangers posed by sewage disposal.

The problems associated with sewage disposal, such as those created by toxic chemicals and viruses are hard to prove, invisible, and their effects are long-term. Environmentalists have a difficult job convincing the public that problems, which are not visually obvious, do exist. Even if they achieve this the public, like the authorities, tends to readily accept the bounds of technological possibility that the 'experts' put forward. The experts believe these bounds themselves.

Sewerage engineers and the authorities which regulate them only recognise certain problems. Hughes has utilized the term "reverse salients" to describe the situation when components of a system fall behind or out of line.[15] These reverse salients may be observed by engineers or the organisations for which they work, and they are redefined as a set of critical problems which the engineers believe they can solve, without radically altering the system. Constant identified "presumptive anomalies" which are presumed to exist when it is predicted by the engineer that a conventional technology will fail under certain future conditions or it is predicted that an alternative technology will do a better job. The second type of anomaly which Constant identified is the "functional-failure" when the technology does not work very well because conditions have changed, allied technologies have changed or other parts of the system have advanced more quickly.[16]

The recognition of a reverse salient or an anomaly, however, depends on the willingness of the technological community or the regulating authority to recognise problems which can be just as subject to interpretative flexibility as artifacts. In other words, reverse salients, functional failures and presumptive anomalies are social constructions rather than realities which emerge and force change.

David Wojick argued that anomalies occurred when standard procedures repeatedly "fail to eliminate known ills" or when knowledge shows up the importance of factors which have previously been incorrectly evaluated. Those contesting the evaluation policy may be outside the paradigm community and their view may be disputed. They can then, Wojick says, turn to the government for a ruling.[17] The question is, does the government listen to them or to the engineers?

Sydney's sewerage system has been perceived by various social groups to be suffering from both functional failure and presumptive anomalies, despite the engineers' faith in the paradigm. In the decades since the system was established the composition of the sewage has changed substantially with the growth of industry and the increased use of inorganic and artificial materials in industrial processes. Conventional sewage treatment methods are

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[15] Thomas Hughes, Networks of Power, chapter 4.

[16] Edward, Constant, 'Communities and hierarchies: structure in the practice of science and technology' in Rachel Laudan (ed). The Nature of Technological Knowledge: Are Models of Scientific Change Relevant?. D.Reidel, 1984, p31.

[17] David, Wojick, 'The structure of technological revolutions' in George Bugliarello & Dean Boner (eds), The History and Philosophy of Technology, University of Illinois Press, 1979, pp244-6..

aimed at removing suspended solids which will settle out of the effluent and breaking down organic material with the use of naturally occurring microorganisms contained within the sewage and in the environment. These methods do not remove or treat viruses, toxic chemicals, heavy metals, organochlorines or most of the grease and oil that is contained in the sewage. In fact some of these substances actually interfere with the microorganisms necessary for secondary and tertiary treatment, killing them off and turning whole batches of sewage 'off'.

Conventional treatment methods were not designed to eliminate pathogens from the sewage, but rather to prevent the waterways becoming a nuisance after the treated effluent was discharged into them. The paradigm was set before viruses were discovered. As a result, although sewage may contain as many as 110 different types of virus, conventional sewage treatment processes cannot be counted on to remove them.[18] Primary sedimentation does not remove viruses or pathogenic bacteria at all. A representative of the World Health Organisation remarked over a decade ago that

> The sanitary engineer who built the early community sewage and water systems did not know about viruses; which is understandable, but many modern sanitary engineers still do not know about viruses; which is neither understandable nor excusable.[19]

Changing community expectations have also created problems for the paradigm on two levels. The public is far less tolerant of the degradation of recreational facilities and more willing to pay for higher degrees of treatment but many treatment plants built when sewage flows were smaller and public expectations lower do not have the space available nearby to expand and incorporate, for example, secondary treatment. This has lead to a solution for ocean outfalls of extending the outfalls under the sea for a few kilometres. Such an ad hoc solution aims at keeping the sewage from view by discharging it at greater depths where it will be more dispersed and may be kept beneath the surface some of the time.

The other change in community expectations arises from the greater environmental awareness that has been manifest since the 1960's and 70's. This awareness has meant that the public is not only concerned with their own health but also with the preservation of river and marine environments and the species that live in them. Very little research has been done into the effects of sewage, especially industrial wastes, on such ecosystems and the consequences of bioaccumulation of certain substances up the food chain.

Sewerage engineers have refused to recognise the full implications of all these problems for their paradigm and have hidden any evidence of environmental problems, such as the accumulation of heavy metals and organochlorines in fish. To the extent that public lobbying of environmentalists have forced them to take notice of these problems they have sought solutions which do not require any radical innovations or changes to the system. They cope with changed situations

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18 Sagar Goyal et al, 'Human pathogenic viruses at sewage sludge disposal sites in the Middle Atlantic Region', Applied and Environmental Microbiology 48(4), 1984, p758.

19 Joseph Melnick, 'Viruses in water: An Introduction' in Gerald Berg et al (eds). Viruses in Water, American Public Health Assoc, 1976, p4.

as best they can by upgrading existing treatment plants, moving points of discharge and adding further stages of treatment to the paradigm.

The problem of industrial wastes is denied by engineers to be a major problem. On the other hand grease is admitted by engineers to be a major problem for swimming beaches near sewage outfalls because the grease, which forms a floating slick on the surface of the sea, makes the sewage field highly visible and leaves obvious traces in the form of grease balls on the sand. Some grease is removed from the sewage during sedimentation treatment by skimming the floating grease from the surface of the sewage in the tank. This has caused engineers to note the inappropriateness of the treatment paradigm,

> most primary treatment plants do a much better job of removing settleables than removing floatables. It would be much better if this were the other way around.[20]

The concern with visibility of the sewage field is substantial because the engineers recognise that performance will be judged by the lay public mainly on what they can see. Without visual indicators, the public has to rely on accepted testing or evaluation procedures for sewerage technology. These, rather than pointing up any functional failure, tend to hide it. Because the paradigm does not specifically deal with viruses or pathogenic bacteria, their presence is not monitored. Authorities, who will not set standards that cannot be met by the available technology, set standards for bathing waters in terms of concentrations of these faecal coliforms which are generally agreed not to correlate statistically with viral counts.

Engineers, as system builders, are able to prevent the system from being radically changed, partly, as Law[21] and Callon[22] have described, by the way they view these systems as being constituted of a number of components which may be animate and inanimate ranging from people, to skills, to artifacts, to natural phenomena. The engineer puts up no barriers between the social, the economic and the political. The engineer, as system builder associates these disparate elements into a form that holds together. Law and Callon argue that engineers treat these various components or elements in the same way, always seeking to change the most malleable and adapting to take advantage of the most durable, in an effort to sustain and hold together the system and achieve the system goals. One thing that Law & Callon do not make clear is that the system goals may become related more to preserving the system than to the original goals that it was set up to achieve.

When faced with a problem that threatens the stability of the system, the engineer, rather than considering building a new system, tries to rearrange or manipulate the system components or perhaps to incorporate a hostile

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20 Paul Ryan, Submarine Ocean Outfall Sewers, internal SPCC report, undated, p11.

21 John Law, 'Technology and heterogeneous engineering: the case of Portuguese Expansion' in Wiebe Bijker, Thomas Hughes and Trevor Pinch (eds), The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. MIT Press, 1987, pp111-134.

22 Michael Callon, 'Society in the making: the study of technology as a tool for sociological analysis' in Bijker et al, The Social Construction of Technological Systems, pp83-106.

environment.[23] If certain social groups are placing importance on problems that are not perceived to be soluble within the system, the engineers may be more likely to concentrate on manipulating or enrolling or discrediting those social groups or reducing their impact rather than coming up with a radical solution to the problem.

In the case of the sewerage system, laws can become, rather than implacable constraints to be heeded, rules that can be variously interpreted and full of loopholes to be utilised; regulatory bodies become open to persuasion and education; and the public becomes an element in the system to be manipulated. For this reason, it is not surprising that the Sydney Water Board is spending massive sums of money on public relations. The compromises built into the legislation and the lack of public input give it enough flexibility to allow its administration to become a negotiation process that can be manipulated by powerful organisations like the Sydney Water Board. Moreover the staffing of the SPCC by engineers and the composition of advisory committees and the Commission with people who adhere to the system have ensured that the legislative process has become part of the system rather than part of the environment of the system.

EXPERT ADVICE AND THE PROBLEM OF POLITICAL AND PROFESSIONAL BIAS

The efforts of engineers to predict and mould public opinion is part of engineering activity and clearly this activity makes any separation of the social and technical unrealistic. Callon, for this reason, has described engineers as sociologists. This is particularly true of sewerage engineers who aim, not so much at being able to predict the acutal performance of the technology they are designing as the perceived performance of that technology. But they also try and control that public perception as well through their predictions and later denials. Engineers treat people like the inanimate parts of their system, as elements to be shaped rather than influences to be listened to. They generally don't like unpredicability and prefer order and control.[24] They attempt to manage public reactions just as they attempt to control nature and various other unpredictable parts of their systems.

The notion of public participation in decision-making and the idea that everyone has a legitimate right to influence public engineering decisions are anathema to the engineer's professional self identity and a threat to expert status. The self-image of engineers as having superior knowledge, being logical thinkers and having a special ability to combine practical matters, such as economics, with theoretical scientific principles means that they see themselves as uniquely able to control public works and solve social problems through the application of scientific principles.

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23 Thomas Hughes, 'The evolution of large technological systems' in Bijker et al, The Social Construction of Technological Systems, p53.

24 A.J.Kirkman, 'The Communication of Technical Thought' in E.G.Semler, ed, The Engineer and Society, Institution of Mechanical Engineers, London, 1973, p182; Robert Perrucci & Joel Gerstl, Profession Without Community: Engineers in American Society, Random House, New York, 1969, pp51-52; William Davenport & Daniel Rosenthal, Engineering: Its Role and Function in Human Society, Pergamon Press, 1967, p73.

Engineers have opposed increased public participation arguing that it would lead to worse decisions. Good decisions are seen as those that lead to more cost-effective solutions. Alternatives can be considered and impacts appraised by weighing the facts, making calculations and predictions and quantifying the benefits and risks. This, it is argued, takes special education, information and experience which the public do not possess.[25] The "ordinary consumer is not generally deemed to be able to appreciate what goes on in science and technology".[26]

Most engineers work in large organisations or bureaucracies. By having control of the intellectual resources and often the organisational resources within those bureaucracies they hold a good deal of power.[27] They are able to filter information reaching the top management or boards and to define the range of options from which those in charge can select, being careful to present the options os that their preferred option is most attractive.[28]

The tendency towards elitism in decision making that engineers have is reinforced by the bureaucratic mode.

> Bureaucracies tend to be secretive, self-serving, non- imaginative, non-risk taking, and susceptible to functional lying....In their relationships with the public, bureaucracies withhold certain kinds of unpalatable information or deliver information in such a way that it distorts facts.[29]

Over the years bureaucracies establish operating procedures and solidify relationships with other institutions which constrain the flexibility of the organisation and limit the options that the bureaucracy will consider.[30] Public bureaucracies in particular can become concerned with maintaining and expanding their control and power rather than achieving specific objectives in serving the public.

Most of the population respect and acquiesce to those who claim to have specialised knowledge. [31] In a complex society with a division of intellectual labour, such relationships are necessary. The abstraction and generalisation that are characteristic of scientific knowledge are necessary in dynamic societies where social and technological change occurs rapidly. Social relationships require trust and the granting of authority to those with specialised knowledge is

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25 Stuart Umpleby, `Is greater citizen participation in planning possible and desirable?', in Godfrey Boyle, David Elliot & Robin Roy, The Politics of Technology, Longman & Open University Press, 1977, p234.

26 Leslie, Sklair, `Science, technology and democracy' in Godfrey Boyle, David Elliot & Robin Roy, The Politics of Technology, Longman & Open University Press, 1977, p173.

27 Joseph, Coates, `Why Public participation is essential in technology assessment', in Boyle et al, The Politics of Technology, p186.

28 Joel Primack & Frank von Hippel, Advice and Dissent: Scientists in the Political Arena, Basic Books, New York, 1974, p38.

29 Coates, `Why Public participation is essential in technology assessment', p186.

30 Primack & von Hippel, Advice and Dissent, pp38-9.

31 Lauriston King & Philip Melanson, `Knowledge and Politics: Some experiences from the 1960s', Public Policy xx, Winter, 1972, p84.

necessary for such society to function.[32] The boundary between granting experts sufficient authority and too much is a fine one however.

It is not only knowledge but also assumptions of rationality and objectivity which lead the public to look to experts for advice and solutions.[33] The public increasingly judges claims to expertise in terms of credentials; academic qualifications and those granted by professional societies. Often however, education is a socialisation process concerned with producing compliant and diligent employees who possess the required middle class values and can be trusted in positions of responsibility.[34]

Membership of professional engineering societies is also based on academic qualifications, references, usually from employers, and responsible work experience, which is dependent on the degree of trust placed in the employee by the employer. This trust has as much to do with loyalty and willing subordination to the employer as with competence and specialised knowledge[35] and these are qualities which do not lead to objective non-partisan advice.

More importantly, credentials may not be specific to the subject area in question and engineering knowledge in particular may not be specific to the problem being publicly discussed. In terms of sewage disposal, commonsense and observation have often proved to have been every bit as valid and accurate (if not more so) in predicting where sewage would go once discharged to the ocean as the knowledge gleaned by engineers from their specially constructed scientific models, float experiments and specialist observations. It has recently been admitted by the authorities in Sydney that common observation is the best way of telling whether the sea is polluted. This comes after years of experts denying the validity of such public observations and will probably disappear once Surfline has gained control over expertise in this area.

Moreover, the technical aspects are only one part of the decision-making process which inevitably involves a weighing up of benefits, costs, values and priorities. There is no reason why technically trained people would be the best at making the final decision, in fact the very specialisation of an expert could well ensure that he or she has a far too narrow view to be able to make good, broad ranging, far seeing decisions.[36]

Whilst credentials may indicate a certain level of education and work experience, they are no guarantee of rationality or objectivity. Engineers, like scientists, have sought to portray themselves as non-political, non-partisan, neutral

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32 Randall Albury, The Politics of Objectivity, Deakin University Press, 1983, p44; Barry Barnes, About Science, Basil Blackwell, 1985, pp82-3.

33 Dorothy Nelkin, `The political impact of technical expertise', Social Studies of Science 5, 1975, p36.

34 Randall Collins, The Credential Society: An Historical Sociology of Education and Stratification, Academic Press, 1979.

35 Robert Zussman, Mechanics of the Middle Class: Work and Politics Among American Engineers, University of California Press, 1985, p158; Peter Whalley, The Social Production of Technical Work: The Case of British Engineers, MacMillan, 1986, pp58-9.

36 Leslie Sklair, `Science, technology and democracy' in Boyle et al, The Politics of Technology, pp173-4.

experts.[37] Nevertheless engineers on public works have necessarily had a close association with those in government. As employees, engineers have sought to fulfil the goals and objectives of those in power and they act openly as advocates of particular engineering schemes.

The dependability and truth of what experts say rests partly on the perceived norms of science, which include the search for truth, honesty and peer review. Such norms, even if they work well when it comes to research work and publication of results, are often not operative for scientists in a public arenas where different conventions and rules can "require them to adopt and defend firm conclusions" despite the existence of uncertainties.[38]

> The layman however is not usually aware that the scientist in such a situation is speaking without that control over his statements. The setting of the courtroom or public hearing of a legislative committee in which scientists speak to laymen, and in which expert witnesses do not criticise one another as they would in the scientific community, permits recommendations made by persons who claim scientific expertise to go unchecked by other experts.[39]

For engineers, there is no norm of truth seeking or peer review, in fact commenting on another engineer's work is considered to be unethical. The solidarity of engineers in the public arena is quite marked, when compared with scientists, for this very reason. Engineers are concerned firstly about their individual status and then about the collective status of engineers and it is often more important not to tarnish that status in the public eye with criticism of other engineers or open disputes between engineers, than to ensure that the truth is revealed.

Moreover engineering work is judged by its effectiveness or ability to achieve the desired goals of employers rather than by professional standards. Publication is not the route to recognition and the details of an engineers work are not usually made public. Engineering codes of ethics, unlike the norms of science, are not part of the self identity of practitioners and they are notoriously loose and difficult to enforce.[40]

The difficulty with enforcing any peer pressure is that engineers give their first allegiance to their employers, to whom they look for career advancement and recognition. Professional control over behaviour is displaced by control in the

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[37] David Noble, The Forces of Production: A Social History of Industrial Automation, Knopf, New York, 1984, p42; Stanley Schultz & Clay McShane, `To Engineer the metropolis: Sewers, sanitation and city planning in late- nineteenth century America', Journal of American History LXV(2), Sept 1987, p399.

[38] Arie Rip, 'Experts in Public Arenas', in Harry Otway & Malcolm Peltu, eds, Regulating Industrial Risks, Butterworths, 1985, p95.

[39] Duncan MacRae, Jr, `Technical communities and political Choice', Minerva xiv(2), Summer 1976, p173.

[40] A.M.Stretton, `Questioning professionalism', in The Engineering Conference, Proceedings of Institution of Engineers, Australia conference, Hobart, 22-26 February 1982, p14; Kenneth Prandy, Professional Employees: A Study of Scientists and Engineers, Faber & Faber, London, 1965, p82.

workplace[41] and this involves quite a different set of behavioural rules, directed at achieving the goals and objectives of the employer rather than displaying objectivity and rationality.

A study of American engineers in the late 1960s found that

> regardless of the extent of administrative duties, level of technical responsibility, and level of supervisory responsibility, engineers are most likely to select "immediate superiors" as the group whose judgement should count most in evaluating the professional performance of engineers.[42]

Preferences after immediate superiors went to fellow engineers, then consumers, then leaders of professional associations with community leaders in last position. The community therefore cannot expect to get objective, truthful nor non-partisan advice from experts employed by private companies or public authorities. It has been observed

> Where particular policy areas become intensely polarized, the "knowledge" drawn into the conflict is likely to mirror the contending positions in the conflict rather than transcending the values at stake.[43]

Not only is expert advice likely to be biased because it is bought but also because the expert will have professional predispositions and biases and also their own personal political views, values and priorities which will be reflected in the advice given.[44] Advisory committees or independent experts might be able to overcome the problem of individual personal biases and the problems of loyalty to a particular organisation but the professional biases of experts still predominate.

> People used to working and thinking in a certain discipline, and who thus tend to see issues in the context of that discipline, inevitably base their advice on a certain set of implicit technological, social and political assumptions.[45]

It is not surprising that on the occasions when the NSW government have called in independent engineers to assess decisions, be they the Sewage and Health Board engineers' decisions or the Water Board engineers' decisions, they have been supportive of the positions taken by the partisan engineers since the choices dictated by an engineering training are necessarily narrow and the economic constraints are universally applied. Similarly, a separate organisation such as the SPCC, set up to regulate the Board's activities, will have very few points of difference with the Board because of its similar reliance on engineering expertise.

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[41] William Rothstein, 'Engineers and the Functionalist Model of Professions' in Robert Perrucci & Joel Gerstl (eds), The Engineers and the Social System, John Wiley & Sons, 1969, p89; Edwin Layton Jr, The Revolt of the Engineers: Social Responsibility and the American Engineering Profession, Cape Western Reserve University, Cleveland and London, 1971; Prandy, Professional Employees, p123.

[42] Perrucci & Gerstl, Profession Without Community, p118.

[43] King & Melanson, `Knowledge and Politics', p93.

[44] Barnes, About Science, pp106-7.

[45] Primack & Von Hippel, Advice and Dissent, p121.

Advisory committees are often set up to reflect appropriate biases by careful selection of members. The setting up of the Clean Waters Advisory Committee is one example which promoted lively parliamentary debate over the extent of government department and industrial representation. Token representation of unions and environmentalists does not provide any real say to these groups and the appointment of these representatives can further subvert the voice of potentially threatening groups. For example the first conservation representative of the SPCC also happened to be on the Board of ICI and was disowned by the environment movement.

A further bias in the setting up of advisory committees can occur because of the avoidance of any experts who have taken a strong public stand on an issue. This also can result in a bias towards the status quo since experts who have never taken a public stand will generally be those who agree with the status quo or who are too frightened to speak out against it.[46]

Government decisions are often defined as technical decisions and the issues at stake also as primarily technical. This is more comfortable for the policy makers.[47] In this way, the decision appears to be subject to objective criteria that can be evaluated by the experts using economic and scientific models, calculations and statistics.[48] Difficult issues such as conflicting interests do not have to be resolved and the alternatives can be compared solely on the basis of cost and effectiveness in solving the immediate problem.[49] It has also been argued that by focussing increasingly on technical issues "we are diverted from more significant and fundamental issues and even start to lose our capacity to deal with them." [50] Expertise in ethics, morals and values is not recognised and these aspects of life are considered to be a matter of opinion.[51]

Moreover, people have in the past treated technological change as inevitable and irresistible to a far greater extent than any other sort of change,[52] especially since technological change has been synonymous with progress. Certainly, Sydney's first sewers were greeted as a step towards greater civilisation and in rural towns all over Australia, people without sewerage systems regard their septic tanks as backward and primitive.

Defining a problem as technical also conveniently hides the political choice and priorities involved and reduces the arguments to arguments over technical details.[53] Those who control "certified expertise" hope that by defining the issue as non-political they can avoid being embroiled in a public debate.[54] Proposals

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46 ibid., p121.

47 Dorothy Nelkin, `The political impact of technical expertise', Social Studies of Science 5, 1975, p36.

48 Dorothy Nelkin (ed), Controversy: Politics of Technical Decisions, Sage Publications, 1984, p18.

49 Nelkin, `The political impact of technical expertise', p36.

50 Barnes, About Science, p101.

51 ibid.

52 James Carroll, `Participatory technology', Science 171, 19 February 1971, p648.

53 Harvey Brooks, `Scientific concepts and cultural change', Daedalus 94(1), Winter 1965, p68.

54 Brian Martin, 'Analyzing the Fluoridation Controversy: Resources and Structures', Social Studies of Science 18, 1988, p337.

can be "thrust upon the public as if they were noncontroversial technical decisions" and without policy makers appearing to be arrogant or undemocratic in doing so without open debate.[55] The justification of major policy decisions in terms of "some purportedly objective knowledge" is seen to be necessary in representative systems.[56] Unspoken objectives such as maximising economic growth and priorities afforded to industrial concerns do not become explicit. Opposition can then be labelled emotional or politically biased, ignorant or irrational.[57]

In this way the debate over sewage reuse can be contained by arguments over the economic value of sewage as fertiliser or water and the philosophical debate over use of resources and sustainability can be avoided. The use of the sewers for trade waste can be discussed in terms of what concentrations of which chemicals the sewerage system can cope with and thereby the debate over the provision of cheap disposal facilities to industry can be by-passed.

It is not to be assumed that experts are fooled by the pretensions that a problem is totally technical. Most engineers are fully aware of the political dimensions of the decisions they make and the advice they give but they cannot make those political dimensions obvious for fear of undermining the faith others have in expertise.[58] They must appear to be apolitical for after all they are not elected and it is their perceived neutrality which allows them to have power.

> a principle function of the apolitical definition of the policy expert's role is the exact opposite of the definition: it provides access to social power without political election.[59]

Decision-makers can make use of the esteem given to expert knowledge and the status given to science in order to justify, legitimise and gain acceptance for their decisions and to give the impression that their decisions have a sound and certain basis.[60] This does not mean that the technical considerations were foremost in making the decision. Rather "specialised knowledge merely becomes another weapon in the decision-maker's political arsenal"[61].

By keeping issues confined to technical discussion, not only do policy makers avoid making their objectives and priorities explicit but they ensure that any argument is confined to an arena in which experts have authority. If it is admitted that a decision has social and political dimensions then it is much more difficult to maintain that only scientists and technologists should discuss and influence it.[62] In this way policy makers are able to use expert judgement to

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55 Dorothy Nelkin & Michael Pollack, `The politics of participation and the nuclear debate in Sweden, the Netherlands, and Austria', Public Policy 25(3), Summer 1977, p355; Martin, 'Analyzing the Fluoridation Controversy', p337.

56 Randall Albury, The Politics of Objectivity, Deakin University Press, 1983, pp6-7.

57 Dorothy Nelkin, `Scientists in an environmental controversy', Science Studies 1, 1971, p254.

58 Guy Benveniste, The Politics of Expertise, Croom Helm, London, 1972, p62.

59 ibid., p65

60 Rip, 'Experts in Public Arenas', p96; King & Melanson, `Knowledge and Politics', pp88-9

61 King & Melanson, `Knowledge and Politics', p100.

62 Sklair, `Science, technology and democracy', p174.

justify their decisions and in any dispute they have an advantage because of their superior access to experts and technical information.

Organisations are able to consolidate a monopolistic position by either acquiring widespread external professional consensus on their proposals or by "creating a large integrated research team whose advice cannot easily be dismissed".[63] The Water Board acquires widespread external professional concensus by using consultants with a good reputation who are unlikely to be questioned by fellow engineers. The use of people with international reputations in the field of submarine ocean outfalls to support the Sydney Water Board proposal has made it virtually impossible for other engineers with lesser reputations or reputations in other areas to credibly question the proposal and they are unlikely to do so, whilst adhering to the whole concept of specialist expertise.

Public access to debate is further limited by the use of specialist jargon and making reports overbearingly and unnecessarily technical and esoteric.[64] Popularisers of scientific and technological fields inevitably meet with displeasure and have low status within expert communities because they are opening up fields which the experts would prefer to be incomprehensible to the public.

By hiring their own experts opponents can either question the evidence put forward by government experts or point to evidence that has been ignored. Debate, however, tends to remain focussed on technical issues rather than the conflicts over values and priorities which are really at the heart of any disagreement.

> Thus power hinges on the ability to manipulate knowledge, to challenge the evidence presented to support particular policies, and technical expertise becomes a resource exploited by all parties to justify their political and economic views.[65]

When the Sanitary Reform League was formed in 1880 to oppose water carriage and ocean discharge of sewage it utilised expertise in the form of written papers and texts, mainly from overseas sources. The members were thus able to inform themselves and use the authority of selected experts to counter the experts quoted and retained by the government. This was easier before engineers took over the field and formed their consensus. Since the formation of a sewerage treatment paradigm it is difficult to find alternative experts in the field.

Occasionally engineers have anonymously voiced their doubts about a particular sewerage proposal but any public expert opposition, and it has been rare, has come from outsiders. Most recently, public expert opposition to the extended ocean outfalls has come from a retired engineer, Bob Brain, who felt he was badly treated by his previous employer but nonetheless had much confidence in his competence in the area in question,Tom Mullins, a marine chemist with the NSW Institute of Technology, and most recently John Easey, a scientist with the Australian Nuclear Science and Technology Organisation. Stop the Ocean

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63 Benveniste, <u>The Politics of Expertise</u>, p126.

64 Sklair, `Science, technology and democracy', p173

65 Nelkin, <u>Controversy</u>, p17

Pollution, the main opposition group to the extended outfalls, has mainly had to draw on expert opinion from written sources, especially overseas sources. Even so they have had difficulty in acquiring the credibility that is accorded to those with qualifications.

The formation of the paradigm has ensured that engineers have become the 'endorsed' group when it comes to sewerage technology. Brian Martin has pointed out that extent of official endorsement a group has will effect their strategy in a controversy. The 'endorsed' group relies on their authority, preferring to avoid or deny any scientific disputes, whereas challenging groups uses the existence of any scientific disagreement to argue for an examination of the evidence.[66] In the sewage treatment debate, the Sydney Water Board has presented knowledge claims about health risks of swimming in polluted water, for example, as uncontroversial whereas opponents such as STOP have highlighted the debate between scientists over the issue and called for epidemiological studies to be carried out in Sydney.

It is useful for policy makers to have controversial decisions legitimised by prestigious experts. In NSW in the nineteenth century when a proposal to put the sewage out at Ben Buckler Point, Bondi, was met with public opposition, an eminent English engineer, W.Clark, was called in to supply expertise and authority to support the proposal, which was opposed because of fears that the outfall would pollute nearby beaches. Clark reported, after very rudimentary experiments, that the point of discharge at Bondi was well chosen and nuisance would not arise[67] but it is clear that the specialised skill and experience of such an eminent engineer were wasted on such an exercise which could have been performed more competently by a local fisherman. Moreover, Clark relied for his conclusions on the evidence of one float thrown overboard and deliberately ignored the possibility of sewage being driven into the Bondi Bay even though this was an important factor in rejecting an alternative proposal.

Legitimation may merely involve invoking an authority as a substitute for evidence[68] or informing the public that the policy maker has consulted eminent experts, even if in fact the experts did not whole-heartedly support the proposal but reported confidentially so no one knows the difference. In the face of public controversy and internal questioning of the 1976 Caldwell Connell report, overseas experts were called in to give the prestigious expert support that would allow the proposal to go ahead. These experts spent less that a week in Sydney and had to give their support with some reservations based on the data supplied to them by the proponents of the scheme. Instances have been reported where officials have selectively published expert reports, have summarised expert reports in a misleading way, have lied about expert reports, have suppressed information available only to them or have manipulated their advisers to ensure a favourable report.[69] The Water Board used Brooks and Harremoes in a way that caused the Board severe embarrassment when the reservations expressed by the experts were later made public.

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66 Martin, 'Analyzing the Fluoridation Controversy', p336.

67 W. Clark, Report to the Government of NSW on the Drainage of the City of Sydney and Suburbs, 1877, pp13-14.

68 Primack & von Hippel, Advice and Dissent, p72

69 ibid., pp34-5.

As media attention has focussed on beach pollution and the new submarine outfalls the Board has claimed that all stages of the project have been reviewed by an overseeing panel of leading international scientists and engineers.[70] This overseeing panel has never been mentioned before and one can only suppose that they were referring to their own consultants, Caldwell Connell.[71] Most recently the NSW government announced a inquiry into submarine outfalls to be undertaken by international experts.[72] The tender advertisement invites inquiries from experts in sewage treatment and diposal technology.[73] This is clearly a move designed to calm public agitation over beach pollution and the performance of the new ocean outfalls by calling in the technical experts although the issues are clearly wider than can be dealt with adequately by specialists subscribing to the sewerage treatment paradigm.

Expertise is not equally available to all those who might wish to use it to support their case and it thus becomes an "instrument of power and privilege".[74] Modern environmentalists often hire their own experts these days but government authorities are always able to hire more experts, more prestigious experts and to limit information about the proposed project to the opposition. Experts, especially engineers, have been reluctant to speak on behalf of government opponents, not only because it would mean opposing other engineers and breaking solidarity but also because, in Australia, such a large proportion of engineers are dependent on the government for either direct employment, consultant work or grants. It is just not worth it to an engineer to jeopardise his/her future in this way.

Those in power not only have better access to the experts but also to information. Organisations can limit outside interference by resorting to secrecy or by not allowing the public enough time to study the huge amount of research data that it has come up with before the decision is made.[75] Secrecy is certainly used by Sydney authorities to limit information available to potential opponents. Without key information opponents can be fairly effectively disabled. The Board's engineers themselves may have some knowledge through education but, more importantly, they have access to the information they obtain and generate in the course of their job. Engineers, by exchanging such information informally with other engineers in other parts of the public service, are able to form an "informal professional network of information exchange" as a "defence against emerging pressure groups with few resources". It becomes a simple matter to expose such groups as poorly informed.[76]

In the absence of Freedom of Information legislation in NSW the public authorities such as the Water Board and the State Pollution Control Commission are able to limit the amount of information that they make available to the public and also to keep internal reports, memos and debates confidential. Moreover there are clauses built into various NSW government acts, including

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70 Sydney Morning Herald, 16th January 1989.

71 Sydney Morning Herald, 28th January 1989.

72 Sydney Morning Herald, 2nd February 1989.

73 Sydney Morning Herald, 8th February 1989.

74 King & Melanson, `Knowledge and Politics', p100

75 Benveniste, The Politics of Expertise, p128.

76 ibid., pp123,130.

the Clean Waters Act,[77] that provide for financial penalties to any person disclosing information obtained by them in connection with their duties in administering and executing the act.

This secrecy enables government authorities to have a better command of the facts and to appear far more knowledgeable to the public but also helps them to suppress embarrassing information and hide internal differences of opinion. It has been suggested that such confidentiality is necessary to protect those experts from outside pressure or retaliation, ensure that internal discussions are frank and open and keep commercial trade secrets or matters of personal privacy from public view.[78] It does seem, however, that the greatest pressure on experts comes from within the organisation for which they work.

Whilst confidentiality is maintained it is therefore fairly easy to create the image that policy decisions and technological proposals are the direct result of an objective analysis of the facts provided by the experts[79] and any disagreement between the experts is kept hidden from the public. Moreover the policy maker remains free not to accept the experts' advice if that advice is not made publicly.[80]

Often a decision about a proposal will precede the detailed investigations, feasibility studies and environmental impact statements which are supposed to be enquiring into that proposal and engineers may be required to prepare a case in favour of a particular project or to argue that it is safe and environmentally sound.[81]

> It is common for heads of organisations and their advisers to accept that their task is to authenticate or justify the policies previously chosen and to deny the validity of the arguments introduced in support of the alternative recommendations made by others. [82]

This requires that investigations be selective and damaging evidence be suppressed.[83] Technical advice can be slanted by using different criteria for collecting data and interpretations. Studies based on diverse premises require different sampling techniques.[84] Detailed studies can be done into areas where the advisers are confident no harmful impacts will be found whilst areas where major problems are likely can be glossed over. The distortions inherent in the resulting large volumes of data will not be visible to those who do not have the time, skill or inclination to examine the reports in detail.

When each of the Sydney ocean outfalls was decided upon the investigations done were careful to prove that the sewage would not return to shore. A million dollars was spent on a feasibility study that took five years to complete. The

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77 Clean Waters Act, 1970, Section 30.

78 Primack & von Hippel, Advice and Dissent, p112.

79 ibid., p112.

80 ibid., p33.

81 Barnes, About Science, p108.

82 Duncan MacRae Jr, `Technical communities and political Choice', p177.

83 ibid., p177.

84 Nelkin, `The political impact of technical expertise', p45

resulting volume was proclaimed as "one of the most intensive oceanographic and marine biology studies ever undertaken in Australia".[85] Tides and major currents were studied meticulously whilst winds were all but ignored. Floats were carefully kept submerged so as not to be influenced by the wind. This was all despite the knowledge, available in engineering texts at the time, that sewage would float and that surface currents were determined by wind direction. The direction of deeper currents was studied but not what happened to those currents as they approached the surf zone.

The impact of toxic sediments on the marine food chain was given almost no serious investigation apart from having a diver looking around some distance from the existing shoreline outfall, a few jump camera observations and a very small sample of fish being tested, the results of which do not inspire confidence. No efforts were made to find out the eventual fate of sewage sludge discharged into the ocean. Similarly the die-off of faecal coliforms was studies meticulously but viruses and pathogenic bacteria were ignored.

The State Pollution Control Commission made a policy decision in favour of submarine ocean outfalls prior to receiving the environmental impact statements for comment. They passed them on to one of their experts, Bob Brain, an engineer. When, instead of giving them the nod, he raised serious objections to the whole study and raised significant doubts about the performance predictions for the outfalls the SPCC ended up exerting considerable pressure on Brain to withdraw his objections and in the end he was put on to other work. Brain's objections were not made public and his reports were not available to myself as a researcher. It is only since Brain has retired that he has made some of his objections public and has agreed to talk about his experience in the SPCC.

The ideology that leads engineers to be contemptuous of public participation in decision making, the lack of access that the public have to expertise and the use, by the government and public authorities, of expertise to legitimate policy decisions all lead to a less than honest and open approach when it comes to dealing with the public.

PUBLIC DECISION MAKING AND THE QUESTION OF ITS BENEFITS

The degree to which public decisions draw upon expertise and the imbalance of access to that expertise has caused several writers to raise questions about the extent to which democracy is viable in a society dependent on experts, given that experts are not usually directly accountable to electorates.[86]

> The power afforded to those who control technical information can threaten democratic principles, reducing public control over many public policy choices.[87]

[85] Caldwell Connell, Sydney Submarine Outfall Studies, M.W.S.&D.B., 1976, letter at front.

[86] Nelkin & Pollack,`The politics of participation and the nuclear debate in Sweden, the Netherlands, and Austria', p334; MacRae, `Technical communities and political Choice', p169; Carroll, `Participatory technology', p652.

[87] Nelkin, Controversy, p14.

There are three ways in which decisions made by bureaucratic organisations employing experts can be influenced by the public; through accountability, representation and participation. Accountability is the usual way and implies that the organisation's policies and actions are open to public scrutiny and regulatory investigation. This form of control is quite indirect and weak and totally dependent on the degree of secrecy practiced by the bureaucracy.[88]

Accountability can be reinforced by regulatory agencies which are supposed to monitor the activities of the organisation, be it public or private, and ensure that it abides by existing legislation and standards in its operations.

> One problem is that these agencies can take on a life of their own - they do not necessarily reflect the interests of the citizens. And once again the citizen is reduced to a state of helpless dependence on 'experts'.[89]

Representation, whereby citizens are able to elect representatives to make decisions on their behalf, is a more powerful form of control in that such representatives can be voted out periodically if they do not perform well. But such control does not extend to experts and officials appointed rather than elected to serve the public interest. Such appointees may be responsible to an elected representative but control is far less direct.[90]

Representation has been the chief mechanism for democratic control of sewerage authorities in Sydney but there has also been a tendency to try and remove these authorities from direct democratic control. The history of sewerage development in Sydney typifies the attitude that public authorities and the engineers employed by them should be able to make decisions without interference from the public. Public protests were viewed with annoyance and concessions to popular demands made reluctantly. The Sydney and Suburban Sewage and Health Board discussions were not open to the public nor did they elicit public opinion. The Sewage and Health Board in fact recommended that a permanent and independent central body be established to administer sewerage matters which had tenured members who would not be directly subject to popular control. It was feared that any body which feared unpopularity would not apply sanitary laws stringently.[91]

Between 1888 and 1924 the Public Works Department constructed new sewerage schemes and the Water Board maintained and operated them, doing some ongoing augmentation work. The parliamentary standing committee on public works which approved these schemes held inquiries to which members of the public, especially representatives such as local council aldermen, were invited to give evidence. These parliamentary committees were made up of members of parliament rather than appointed experts and although they gave more weight to expert evidence, they were also sensitive to the opinion of voters in these

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88 David Elliot & Ruth Elliot, `Social control of technology' in Godfrey Boyle, David Elliot & Robin Roy, The Politics of Technology, Longman & Open University Press, 1977, pp20-21.

89 ibid., p21.

90 ibid., pp21-22.

91 The Sydney City and Suburban Sewage and Health Board, Eleventh Progress Report, 1876, p4 and Twelfth and Final Report, 1877, p8.

matters. During this period some proposed sewerage schemes were actually stopped because of local community opposition.

When the Board became totally responsible for sewerage schemes in 1924, the public hearings ceased and the opportunity for local residents to have a say became limited to lobbying in the form of letter writing and deputations to the Board, as well as going to the media. The Water Board was an organisation whose higher strata were almost all engineers and the Board, which had representatives from various regional areas, had the power to authorise sewerage proposals but this was usually a financial consideration and they usually bowed to the expertise of the engineers when it came to which technology should be used. In this way the choice of technology became an internal matter for the engineers to decide without interference from the public who only objected when an already installed technology gave rise to a nuisance.

When the public complained in this way, the nuisance was routinely denied, blamed on other sources or shrugged off as only happened infrequently. Proposals that were unpopular because of a fear that a nuisance would be created, often only affected a local area (with perhaps one representative on the Board) and the other members of the Board could be relied on to push it through, whilst the public was reassured and 'educated'. Treatment was kept to a minimum whilst representatives of beachside suburbs remained a minority on the Board.

Being a semi-autonomous public authority the Board was not directly responsible to the parliament and, because of its make up, was far less responsive to public opinion than a government department or municipal council. This autonomy enabled the Board to be fairly contemptuous of public complaints, either dismissing their validity out of hand or responding with the arrogance of one beyond reach or accountability. In 1929 when the media spread the scandal of polluted beaches across their pages, the Board responded that it would do nothing and that nothing needed to be done. Even the Eastern suburbs representative on the Board denied the pollution on the beaches, probably because he realised that nothing was going to be achieved by complaints and local businesses resented bad publicity.

It is ironic, in fact, that the Board was created as a statutory body to remove it from direct public pressure so that it could carry out the unpopular work of sanitary reform and yet that very remoteness from public pressure meant that when environmental concerns became more popular, the Board could retain old fashioned attitudes toward the environment with relative impunity.The State Pollution Control Commission was established in 1972 and provided the opportunity for the Board's activities to be more closely regulated. In practice however, the liaison between the two organisations was very close with interchange of personnel and no real independent stance.

In 1983 the state government moved to bring the Board more closely within its control, making it directly responsible to the Minister for Resources and with a government appointed general manager. Local government representatives were not put on the Board as had happened prior to 1972 because it was argued that the benefits of having such representatives on the board could be met by encouraging community participation and the systematic canvassing of community opinion and the opinion of interest groups such as local government to ensure their views were taken into account in decision making.[92] But rather than consulting with the public, except where it was required to under the provisions of the Environmental Planning Legislation, the Board chose to deal with the public through massive public relations and propaganda campaigns. It was a policy of persuading the public that the experts knew best.

> Those in favor of rapid applications of technological development often believe that opposition comes from the 'irrational worries' of 'poorly informed' people. To overcome this, many governments and large companies have launched information campaigns and tried to improve the dissemination of information, intending to counteract the appeal of arguments against certain technological developments and to enhance trust in official decisions.[93]

However, the presentation of such information, because it is designed to persuade, is often presented by public relations people in a way that can easily be perceived as mere propaganda.[94]

The Minister responsible for the Board and his/her government are susceptible to public pressure as elected representatives, but the State body represents a wide range of interests and many people who have no interest in Sydney's sewerage system or the cleanliness of Sydney beaches. In places where sewerage is under the control of local government authorities, local people have more say. In Wellington, New Zealand, for example, the Wellington City Council lost office because they intended to install a sewerage disposal system that citizens felt was not good enough.[95]

A State government is most unlikely to lose office over such an issue unless it can be made to assume wider importance, through its effect on NSW's tourist industry for example. Moreover, there seems to be a defacto bipartisan policy on sewerage treatment despite the rhetoric, given that both major parties have presided over the submarine ocean outfalls project which has been almost twenty years in the making. Voters therefore do not really have a ballot box choice on this issue.

Representative democracy has therefore not been effective in Sydney for allowing citizen's views to directly influence technological decisions to do with sewerage treatment and disposal, nor in other areas of public policy that impact on local environments. For this reason there have been calls for more direct participation in technological and development decisions. Mechanisms such as consultation on environmental impact statements, public enquiries and membership of community spokespeople on committees have all been used in Sydney to meet the public demand for greater participation.

Ann Richardson in her book on "Participation" differentiates three main arguments for advocating increased participation in government decision, firstly

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92 Dr. R. McIver, Report of the Ministerial Task Force to Review Sydney Water Board, 31 August 1983, p47.

93 Michael Pollack, 'Public Participation', in Otway & Peltu, Regulating Industrial Risks, p78.

94 ibid., p78.

95 Interviews with Ian Lawrence, former Wellington Mayor & John Blincoe, new Councillor, Wellington City Council, Wellington, February 1988.

that it is the fairest system of government, secondly that it is important to the well-being of participants and thirdly that it leads to better decisions. The first argument rests on the idea that those who will be affected by decisions should have a right to influence those decisions. She points out that it can also be argued that those who bear the costs of these decisions should have the sole right to determine them.[96] In the case of public sector technology, the two arguments are not necessarily contradictory because there is considerable overlay between the people who pay for the technology through rates and taxes and the people who are affected by it. This is certainly the case with Sydney's sewerage system.

Another reason to improve participatory processes, as outlined by Richardson, is that they give dignity to those involved and affected, they help in the development of individual capability and awareness and help to create a well informed, responsive, involved citizenry. However the ability of participatory processes to achieve these ends may be questioned.[97]

Of more interest to this thesis is whether greater public participation would affect public sector engineering decisions and whether such effects would be desirable. There are two ways of looking at this. Firstly one could see increased participation as an aid to policy makers who would have more information about what services were required, the limits of public tolerance, and various other forms of feedback.[98] At first, some governments believed public participation "would lead to a smoother acceptance of controversial technologies and to the restoration of confidence in official decision-making institutions."[99] Certainly engineers, generally, do not seem to view participation to be beneficial. Rather they see it as being a time consuming, expensive and extremely difficult, if not impossible procedure. How do they know who represents community opinions, how do they survey everyone, what about the very different opinions that people hold?

Another way of viewing increased participation is in terms of the redistribution of power that would be effected.[100] This is more likely to be the reason that engineers, and those who presently have power in public policy making dislike the idea; it infringes on their autonomy and threatens to reduce their power. Here it is assumed that there is some conflict of interest between those who are affected by a decision and those who make it. This may be disputed when policy makers are elected. In the case of Sydney's sewerage system however the interests of wider State electorate may well differ from the interests of Sydney beach users for example. Certainly, the priorities of sewerage engineers as a tight knit professional group that is well entrenched in a technological system and paradigm differ from the interests of beach users and environmentalists.

The claims by the Water Board that they are acting in the interests of the community have a very paternalistic ring to them when they will not make vital

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96 Ann Richardson, Participation, Routledge & Kegan Paul, 1983, pp52-53.
97 ibid., pp54-60.
98 ibid., p61.
99 Pollack, 'Public Participation', p77.
100 Richardson, Participation, p63.

information available to community groups and the media. Despite the recent admissions by a Board's spokesman of past secrecy, little has changed since.

> In the past, there were problems. The board was run by engineers. That is no longer the situation. Yes, perhaps there was too much secrecy. No, not secrecy. It just never occurred to them to let the public know. All of that has changed now.[101]

Nevertheless the Board will not divulge to journalists important information such as the total concentrations of restricted substances in sewage discharged (including sludge) and the removal efficiencies of the treatment plants. It is rumoured that a second bioaccumulation study has been done but the results of that have not been made public either.

Another argument against participation is that most people do not really want it. They simply don't have the time or inclination to inform themselves sufficiently to be able to assess the situation and they would prefer to delegate the responsibility to others. Relatively few people read the environmental impact statements for the submarine ocean outfalls and even fewer made submissions. The current dissatisfaction with the performance of the Water Board is not necessarily a dissatisfaction with institutionalised control of sewerage but rather with the particular incumbents of the Board. This attitude was reflected in the recent calls by the Australian Democrats to sack the sitting members of the Board.[102]

Yet this may well reflect a popular misunderstanding of the process of engineering decision-making. The current situation is more the result of social structures, professional ideologies and previous practice than individual choices. Whilst influence on decision-making is confined to an alliance of engineers and bureaucrats, and whilst those decisions and the relevant information remains confidential, there is danger that the shortcomings of the technological system will not be recognised by the decision-makers.

It is only when the decision-making process is opened up to scrutiny, that those outside the system, in particular environmentalists and community groups acting on behalf of the wider community, can alert the general public of the problems and pressure can be applied for change. Michael Pollack has observed that "relatively open, adversarial systems" combined with "public and intervenor-group lobbying" tends to be more effective than the establishment of consultative procedures.[103]

Mechanisms for public participation and consultative procedures that are controlled by policy makers may not achieve this opening up. Those in power are able to control the structure of the decision-making agenda, lay down the boundary conditions for participation, define the scope of discussion, determine which types of argument will be considered, and generally determine the limits

101 Sydney Morning Herald, 7th January 1989.
102 Sydney Morning Herald, 10th January 1989.
103 Pollack, 'Public Participation', p82.

of legitimacy.[104] Moreover, where participation is introduced as an attempt to obtain approval for decisions or to aid policy makers rather than redistribute power, the impact of participation is carefully limited.

The question remains, whether the Sydney community would chose a different form of sewage treatment and disposal if they were fully informed of the uncertainties and consequences and disputes associated with each option and whether widespread dissatisfaction with the range of options offered by the sewerage treatment paradigm would force a revolution in sewerage treatment. Recent events suggest it might. The coverage in the media of the issue in recent weeks has been heavier than in the past and the issue seems to have captured public attention in a way that has not happened since the 1930s when it was proposed to duplicate the Malabar outfall. This follows similar media attention to ocean pollution issues overseas following a very hot North American summer accompanied by heavily polluted beaches and the death of thousands of seals in the North Sea that were believed to be weakened by industrial pollution of the oceans. Already novel sewerage treatment processes have been coming out of the woodwork,[105] Although these particular treatments may not be promising they are indicative that research may once again be directed towards innovation in sewerage treatment methods.

Increased public involvement in other areas has led to the growth of governmental regulation, changes in industrial strategies as well as the establishment of new research and development priorities.[106] Certainly public involvement provides a counter to narrow professional viewpoints and allows for input on environmental and social impacts of technological projects that involved engineers may be prone to ignore or give secondary importance to.

CONTROVERSY, CHANGE AND CONTROL OF TECHNOLOGY

At the beginning of this thesis I set out to answer some fundamental questions about the nature of technological change and its control. Firstly, is technological change self-perpetuating? Certainly not in the case of sewerage technology. If technological change means innovations in technology, then it can be seen that such change is carefully controlled within a paradigm that directs and paces innovation. If technological change is taken in a broader sense to embrace all new technological projects then the only way in which sewerage technology can be seen to be self-perpetuating is in terms of the way past decisions shape later ones because of the momentum created by physical infrastructure, vested interests, and committed organisations and people.

Are the adverse consequences of technologies inevitable? In this case study, most of the adverse consequences were predicted in advance. Decision-makers chose to ignore or not believe warnings of environmental consequences because they had other priorities. The environmental degradation that has accompanied ocean outfalls has resulted from conscious decisions by policy makers to use the ocean

104 David Dickson, The New Politics of Science, Pantheon Books, New York, 1984, p220; Pollack, 'Public Participation', pp80-81.

105 Telegraph, 21st January 1989; Telegraph, 24th January 1989; Australian, 24th January 1989.

106 Pollack, 'Public Participation', p83.

for disposal because it was cheapest and most convenient to do so. Environmental costs which are usually long-term were not included in the cost calculations because shorter term objectives were given priority.

Who controls technology? This is the most difficult question. Who actually makes the decisions, determines the outcomes? Is it the engineers, the politicians, the public? In public sector engineering technology an alliance of politicians, engineers and bureaucrats hold power but this alliance is not all powerful. The delicate balance between them can easily be upset by massive public discontent. Whilst voters are disinterested, politicians tend to be disinterested as well. In this situation, engineers are able to determine public policy in the area of sewerage technology, provided they minimise costs and work in the interests of their employers. They have learnt during such times that their autonomy depends on the thriftiness of their projects, and they have sought to protect politicians from voter backlash by manipulating public opinion about the consequences of this thriftiness, which is inevitably pollution. Their autonomy has depended on this too. For in times of widespread public agitation, politicians step in and assert their authority.

Nor is the public, one amorphous mass but rather various groups have various interests. Capital and those who represent industry have influence because their interests are identified as interests of the State. The provision of a cheap industrial waste disposal system is provided because of the perceived economic benefits. The Water Board's workforce finds that its interests lie with more treatment because of the construction, maintenance and operating work that would be involved. Women have very little influence because of their minimal role in the engineering profession, as elected representatives and in higher levels of government bureaucracy but as beach users, residents, parents, and ratepayers they have interests.

Sydney beach users have in the past conflicted with residents of unsewered suburbs, but as the proportion of unsewered suburbs has decreased, so has the counter lobby in Sydney. The willingness of ratepayers to pay more for environmental protection is also increasing although there have been recent attempts to inflate the costs of secondary treatment in order to deflate the demands for it. NSW voters outside the Sydney area can be enrolled in the debate by references to the state's fishing and tourist industry.

The control of technology is therefore shared in a way that is fluid and changeable. Each party seeks to consolidate its own power, and the engineers as a constant, cohesive group with a certain amount of expert authority have been the most successful at this, because of the key positions at the design and conception stage and through their ability to socially construct a knowledge base that will support their preferences. Yet their very success has occurred at the expense of the environment and in the end it could be their undoing. Their standing in the community is dependent on their good works but they are increasingly identified with environmentally damaging works. The solidarity which has effectively prevented alternative engineering views from being put may also mean that all engineers are branded as environmentally insensitive. And their manipulation of both politicians and public may be becoming too obvious and cause them to lose their image as impartial, objective experts.

It remains to be seen, as the current battle between beach users and the Water Board reaches a head, just who will win. Is the strength of mass indignation, fed by the media, enough to force the politicians to overrule the engineers in the Board? A recent poll showed that 64% of Sydney-siders were willing to pay higher taxes in order to prevent pollution.[107] How will closure be attained in this latest stage of a controversy that has been waxing and waning for over one hundred years? History stands on the side of the engineers and bureaucrats at the Board but the future is never predictable.

[107] Sydney Morning Herald, 13th February 1989.