

Difficult Data: Boundary Dynamics, Public Engagement and Bridging Technologies in a Science/Policy Controversy

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Abstract In 2001, the New Zealand Ministry of Health (MoH) contracted the Institute of Environmental Science and Research Ltd. (ESR) to undertake a serum dioxin study to determine exposure (current and historical) to dioxins for residents living in close proximity to the former Ivon Watkins Dow chemical plant in Paritutu, New Plymouth. In the years that the plant had operated, a number of activist groups had organised in the community to ask the government to respond to their concerns about possible exposure and any links to adverse health effects. The members of these groups were angry and frustrated. They distrusted industry and the various government agencies involved, and felt that previous scientific studies had marginalised their concerns. This paper explores the processes that enabled ESR to work with the community to produce a robust scientific study. Key dynamics, lessons, methods and mechanisms critical to the success of this intervention are appraised. This paper offers theoretical reflection on boundary work between science, policy and community and focuses on the challenges in including local knowledge to produce ‘useable knowledge’ in this case.

Keywords Boundary critique · Community consultation · Conflict · Interdisciplinary · Dioxin exposure · Local knowledge · Rhetorical bridging · Science · Policy

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1 Introduction

This paper presents a case study of persistent conflict between community and local and national government arising from claims of environmental pollution and possible human health effects. Recent work investigating community allegations of dioxin exposure is examined, and theoretical frameworks introduced that help illuminate the relationships between government, science and community. Strategies directed at community involvement in the co-production of the scientific design and interpretation of findings are reviewed, along with formal and informal mechanisms for reflexivity, including peer review and ‘rhetorical bridging’ (Hoppe 2002, 2005). It is argued that reflection on boundaries is important in enabling science and policy agencies to work effectively, convey uncertainty and manage expectations in order to provide useable knowledge in science and technology controversies. Underlying the boundary work and production of ‘useable knowledge’ is a story of community inclusion and exclusion. Researchers employed by the research institute contracted to determine the exposure of residents to dioxins in a local community provide an account of how ‘difficult data’ was negotiated within science and policy settings to produce ‘useable knowledge’ to support ongoing boundary work between the government and community.

Firstly, we explore the dynamics of marginalisation central to the dioxin conflict using theories of boundary conflict (Hoppe 2002, 2005; Midgley 1992; 2000). Secondly, we discuss reflexivity as a feature of the multi-disciplinary intervention that enabled the aspects of the conflict to be negotiated focusing on science and community, and then science and policy settings. Finally, we discuss the importance of rhetorical bridging as an approach that helped secure temporary agreements within the conflict.

2 Background

In October 2001, the New Zealand Ministry of Health (MoH) contracted the Institute of Environmental Science and Research Ltd. (ESR) to conduct a serum dioxin study that would assist the New Zealand Ministry of Health to investigate allegations of exposure (current and historical) to dioxins for residents living in close proximity to the former Ivon Watkins Dow (IWD) chemical plant in Paritutu, a suburb of New Plymouth in the North Island of New Zealand. Anecdotal accounts had been circulating in the community for a number of years that people had been exposed to dioxins—a family of environmentally persistent chemicals considered a risk to human and environmental health—from the IWD agrichemical company. Operating as Dow Agrosciences, the IWD plant at Paritutu continues to manufacture various agrochemicals today. The agricultural chemical product 2,4,5-T¹ was manufactured at the IWD Paritutu plant

¹ Dioxin, primarily (2,3,7,8-TCDD), is an unintentional by-product of the 2,4,5-T manufacturing process. It is formed from a chemical reaction occurring between chlorophenoxy starting materials, and, though of low volatility, can nevertheless be released in sufficient quantities through emissions during production to occur as an environmental contaminant. Though TCDD is a known carcinogen, it is not known to directly damage DNA. Therefore, epigenetic mechanisms are assumed to be involved in its mode of action in the body. Susceptibility and response in terms of human health is therefore complex and poorly understood. Once in the body, dioxins generally accumulate in fat and persist over time, with TCDD having an estimated elimination half-life of between 7–11 years depending on age and body fat content (Institute of Medicine 2001, 2004; US EPA 2003; WHO 1998).

from 1962 until 1987, by which time the production and use of 2,4,5-T was banned in many other countries because of environmental and health concerns (Brinkman et al. 1986).

At the time the IWD plant was built in the early 1960s, the Paritutu area was occupied by a handful of family farms, with residential housing adjacent to the chemical plant later approved by local authorities. By the mid-1960s, a number of residents reported unexplained health problems which they were concerned may be linked to dioxin exposure. These included various cancers, multiple sclerosis, chronic fatigue, skin disorders, miscarriages and reproductive issues and foetal abnormalities. Throughout the 1970s and 1980s, community activist groups had formed to raise these concerns with government and industry.

The New Zealand MoH had determined that a serum study to test the dioxin levels in the blood of selected residents of Paritutu, to ascertain exposure, would form the scope of ESR's science investigation. While we used 'action research' (AR) principles² to guide our approaches to community involvement, limitations existed on the extent to which ESR could respond to the community's concerns. Health concerns and health data for instance, were not included in the ambit of ESR's investigation, which was focused on determining if exposure to dioxins had in fact occurred. It was important that the study was conducted in such a way that the process and conclusions would be supported and accepted by the community. Building trust and lessening the tension between science, government agencies and community organisations were key goals. Co-production was a key feature of the boundary work done by ESR, yet questions remain about the extent to which this study was able to be transformative in relation to an AR paradigm (Reason & Bradbury 2001). Although the community's involvement and ownership of the study design was important, for a number of reasons it was often difficult to translate the ideals of inclusive participative design into practice in this setting.

There was recognition from the then government that science alone would not resolve the conflict. This shaped a decision to separate the study into two phases where consultation, relationship building and stakeholder management within phase I would precede and inform phase II, a scientific study to test dioxin levels in the blood (serum) of selected residents. This was an essential shift from previous government-funded studies (Brinkman et al. 1986) which had involved doing investigations and then engaging with communities when research data was available.

Responsibility for conducting the investigation into non-occupational exposure to dioxins among residents of Paritutu, was given to ESR by the Ministry of Health. Prior to this, the Ministry of Health had conducted a scoping study and held several meetings with stakeholders and residents³. ESR's team was introduced to the

² Action research principles utilised included active listening and a cycle of shared learning and reflection with the affected community and key stakeholders to explore the problem context, and design an appropriate methodology for serum collection and analysis (Reason & Bradbury 2001; Wallerstein & Duran 2003).

³ The Paritutu serum dioxin study was undertaken in context of a wider 'whole of government' policy agenda and heightened public interest in dioxins. Other activities included the Ministry for the Environment's programme to measure dioxin serum levels in the NZ population, concerns of exposure to dioxins and PCB's for sawmill workers in Whakatane, and the NZ Vietnam Veterans Associations claims of exposure to dioxins.

Paritutu Community Liaison Group, a multi-stakeholder group established by the local health authority that comprised of local activists,⁴ central and local government agencies,⁵ local iwi⁶ and other non-government organisations and community group representatives.⁷ Several meetings were held throughout the initial 6-month consultation phase of the project, as well as one-on-one discussions. A multi-pathway exposure model emerged from these discussions that provided a robust methodology for testing to measure serum dioxin levels. Specifically, this approach helped assure the community that those most likely to have been historically exposed to dioxin were selected for inclusion (Baker et al. 2003; Fowles et al. 2004; Fowles et al. 2005).

The exposure study combined a number of medical, environmental science and social science approaches (Fowles et al. 2004; Fowles et al. 2005). The methodology included the use of questionnaires, soil sampling⁸ and spatial analysis, coupled with multi-pathway exposure and toxicokinetic modelling. Blood samples were taken from 52 volunteers having lived for 3 or more years in Paritutu between 1962 and 1987. A general increase in 8-tetrachlorodibenzo-*p*-dioxin (TCDD) serum concentrations was observed with the increasing age of the participant. The highest and second highest TCDD serum concentration of 33.3 ng/kg lipid and 25.4 ng/kg lipid were recorded, respectively, for a 79-year-old male and a 76-year-old female. The peak concentration of 33.3 ng/kg lipid was 11 times higher than the 1997 national average serum concentration for males over 65 years, or approximately 17 times greater than the national average projected to 2004⁹. Both the predictions from the multi-pathway exposure modelling and the actual results from the serum dioxin testing showed levels of 2,3,7,8-TCDD similar to those that had occurred in Zone B in Seveso, Italy, a well-recognised dioxin exposure incident (Smith & Lopipero 2001). Considerable uncertainty remains however over the actual times and extent of the exposure incidents in Paritutu.

This case of dioxin exposure had all the hallmarks of an 'intractable policy controversy' and much of the conflict appeared patterned, repeated and unresolved (Schon & Rein 1994). Both the MoH and ESR had been hopeful that a well-designed scientific study and process of engagement would help alleviate some of this ongoing conflict. The project aimed to integrate often divergent viewpoints and achieve 'useable knowledge' in the form of temporary agreements on fact and strategy (Lindblom & Cohen 1979; Scott & Walshman 2005). The study design integrated criteria for scientific inquiry with local data sets, and where possible, encompassed local knowledge, practice and concerns. Furthermore, data from previous government studies were revisited and appraised in new ways. A number of

⁴ The activist groups mobilised specifically for the Paritutu dioxin issue at the time of the study included Dioxin Investigation Network, Dioxin Investigation Action Group, Dioxin Legal Action Group, Poisoned Peoples Assn., and Responsible Intelligent Members Progressing Against Corruption.

⁵ The key central and local government agencies included the NZ Ministry of Health, NZ Ministry for the Environment, New Plymouth District Council, Taranaki District Health Board, and the Taranaki Regional Council.

⁶ Māori with traditional connection and authority over the Paritutu area, in this case Ngati Te Whiti Hapu.

⁷ These included the Paritutu Residents Association, the local Multiple Sclerosis Society and the local Cancer Society.

⁸ Soil sampling and analysis was undertaken in a complimentary study funded by the Ministry for the Environment (Pattle Delamore Partners Ltd 2002).

⁹ For a more detailed discussion of the ESR study methods and results see Fowles et al. (2009).

mechanisms that facilitated critical reflection on the study design and interpretation of results were initiated within the research team, between the research team, clients and community and with the international science community. However, while community concerns were heard and validated, community knowledge and data could only be incorporated in limited ways. This paper reflects on the dynamics of producing robust, valid and useable knowledge that traverses the boundaries between government, science and community.

2.1 A History of Marginalisation of Community Concerns

Concerns over exposure to dioxins had attracted increasing media exposure and public disquiet, accentuating the unpredictability and volatility of exacerbating the situation in Paritutu. Since the plants' construction in the early 1960s, various community activist groups had organised protest activities adjacent to the IWD plant and expressed their concerns to local and central government authorities. For the activists, the lack of scientific evidence prior to the ESR report did not mean that local people were wrong in thinking they had been exposed to dioxins: rather, that the previous science had been wrong. Activist groups distrusted industry and the various government agencies involved and felt that previous Ministerial Inquiries (Brinkman et al. 1986; Brinkman et al. 1987) and scientific studies funded by various government agencies had marginalised their concerns (Buckland et al. 2001; Coster et al. 1986; Taranaki Regional Council 2001).

A central feature of the longstanding conflict between the government and the Paritutu community was the way government agencies had been perceived as dismissing community concerns about dioxin exposure and adverse health effects. Local health agencies, for example, had received numerous telephone calls and accumulated written letters from concerned residents over the years, and although this data was collected and filed, typically it was not followed by appropriate action as far as the community was concerned.

A previous Ministerial Inquiry undertaken in the 1980s had found no evidence of dioxin exposure (Brinkman et al. 1986, 1987). More recent government studies showed that the rates of illness in the Paritutu area were no higher than comparable populations (O'Connor 2001, 2002). As a consequence, officials could not explore community concerns about links between possible exposure and ill health. The historical investigations seemed to suggest that community concerns were misplaced. However, scientific methods for detecting dioxin exposure were poorly developed at the time (Coster et al. 1986). Moreover even if exposure could be proved, difficulties existed, and still exist, in correlating dioxin exposure with an adverse health effect. Indeed, this connection between exposure and health continues to be the focus of international research, particularly relating to the claims of USA Vietnam Veterans and other occupational cohorts. The most comprehensive studies in this area suggest that a very limited number of health issues can be linked definitively with dioxin exposure (Institute of Medicine 2001, 2004, 2008).

Major tensions developed among science, policy and community actors as community groups sought information about the distribution and effects of dioxin. At the heart of the controversy was scientific uncertainty about how to detect the presence of dioxins in the environment and/or in humans, how to document the

relationships between dioxin exposure and possible adverse health outcomes and what would constitute scientifically ‘valid’ data. It is difficult to prove relationships of statistical significance between dioxin exposure and particular negative health outcomes, due to confounding factors such as smoking, diet, lifestyle, occupational or other exposure to dioxin related compounds; significant delay between an exposure incident and an adverse health outcome; cohort tracing and limited statistical explanatory power resulting from the small size of the Paritutu population. Such methodological difficulties and the lack of scientific evidence of exposure had led previous government administrations in the 1970s, 1980s and 1990s to believe there was little justification for further scientific investigation or policy responses encompassing social justice, compensation and care.

In exchanges with the ESR project team, spokespeople for the activist groups repeatedly alleged decades of ‘denials’, ‘cover ups’ and ‘lies’, conveying a strong distrust and lack of confidence in government, science and industry and a sense of marginalisation (Irwin & Wynne 2003; Sandman 1993; Schon & Rein 1994). That officials were not perceived to actively pursue their concerns and suggested actions reinforced the activists’ impressions that the government was not responsive or interested in the issue. Also, apparent was a clash of different knowledge systems, and a conflict around ‘the facts’ as identified in ‘expert’ professional definitions and discourses of science, medicine and policy, and in ‘lay’ or local knowledges grounded in the observation and experiences of those living adjacent to the IWD plant, and the information derived from various community organised internet sites (Bauer et al. 2007; Horlick-Jones et al. 2007; Powell et al. 2007; Slovic et al. 2001; Wynne 1992, 2003; Young & Matthews 2007).

2.2 Boundary Conflict and Boundary Critique

Midgley’s (1992, 2000) theory of ‘boundary critique’¹⁰, specifically his approach to boundary conflict and marginalisation, is useful for understanding the dynamics in this case. He demonstrates how patterns of inclusion or exclusion of stakeholders and issues can contribute to particular groups feeling that their concerns are *marginalised*—neither fully included nor excluded from the system, and often subject to strong labelling and ritual treatment.

Previous government investigations into dioxin exposure had maintained an official position that the risks from 2,4,5-T manufacture and use were well managed, that pollution of the environment had not occurred and that any health concerns expressed by community were unfounded. The outcomes of these investigations consolidated the relationships that existed between various government agencies and scientific professionals. Many in the local community however considered that their concerns had been marginalised.

If scientific uncertainty contributed to previous governments’ lack of attention to public concerns about exposure to 2,4,5-T, so too did economic factors (Dew 1999). Wildblood-Crawford’s (2008) thesis drew on archival data to explore the socio-political dynamics around this issue, providing a comprehensive analysis of the IWD

¹⁰ A normative theory about the need for reflection on boundaries and value judgements during interventions (Midgley 2000: p. 135).

plant's operation and emphasising how vitally important the continued manufacture of 2,4,5-T was to New Zealand's pastoral and agricultural economy. Over many years this was the cheapest and most effective way to control the introduced weed gorse and other tough weeds in pastures. New Zealand became recognised as the 'heaviest user of 2,4,5-T in the world', and although the chemical was banned in many other countries because of environmental and health concerns, 2,4,5-T products continued to be manufactured at Paritutu until 1987 (Brinkman et al. 1986:19). At this time, the New Zealand government's official position was that community health and exposure concerns were unwarranted. As recently as the early 1980s, a senior medical official of the New Zealand Department of Health stated on national television that 2,4,5-T was 'so safe that you could drink it' (Read 2006: 87).

In Paritutu, the community activists made repeated accusations of government dishonesty and 'cover up'. For the current central and local government officials, as well as local residents not aligned with the activist groups, these accusations and exchanges reinforced the view that the activists were 'unruly', 'untrustworthy' and 'difficult'. 'Talking past' rather than 'talking with' was characteristic of interactions between community and government representatives. The process is represented diagrammatically in Fig. 1 below.

Intractable policy controversies are characterised by dynamics of marginalisation, ritual and repetition. The process is expressed symbolically in ritual which, in turn, reinforces the dynamics of the total system (Midgley 2000). During ESR project team conversations with community activists, it was evident that a pronounced 'insider/outsider' dynamic existed. The boundary between 'us' (activists) and 'them' (local and national government, science and industry) was highly visible (McKenchnie 2003). These insider/outsider dynamics were reinforced in the discourses of professionals in the various government agencies. Officials often adopted a 'public deficit model'¹¹ of science and policy and viewed the activists as confused, poorly informed, and irrational (Wynne 1992, 2003). These underlying conflicts were evident in frequent, often heated, interactions (meetings, telephone calls etc.) which reinforced the previous impressions of participants that they were on opposing sides of a conflict. The situation seemed in some respects 'unruly', yet also exhibited the features of a scripted, patterned and highly ritualised conflict (Funtowicz & Ravetz 1992; Needleman 1987; Schon & Rein 1994; Tuathail et al. 1998).

Midgley's model also supports further exploration of the relations between the government and the affected community, showing that, whilst the lay and expert knowledge systems had been mostly 'talking past' each other, a need for 'reassurance of community health' in fact existed as an underpinning goal for both, and was a key 'anchor point' for the controversy (Douglas & Wildavsky 1982; Midgley 1992, 2000). This convergence of dialogue on the importance of community health was vitally important in 'moving forward', a phase used frequently in the course of the negotiations relating to the research design of the ESR project.

This diagram utilises Midgley's model of boundary conflict to deepen an understanding of the areas of commonality and divergence between science and the affected community. As indicated in the dotted line of the circle on the right of Fig. 2, the

¹¹ The 'public deficit model' of science is well utilised and debated within the STS literature. Very simply, this ideological stance strongly demarks 'lay' and 'expert' knowledge, implying that the public lacks the necessary expertise to understand complex science and adequately consider its impacts and implications.

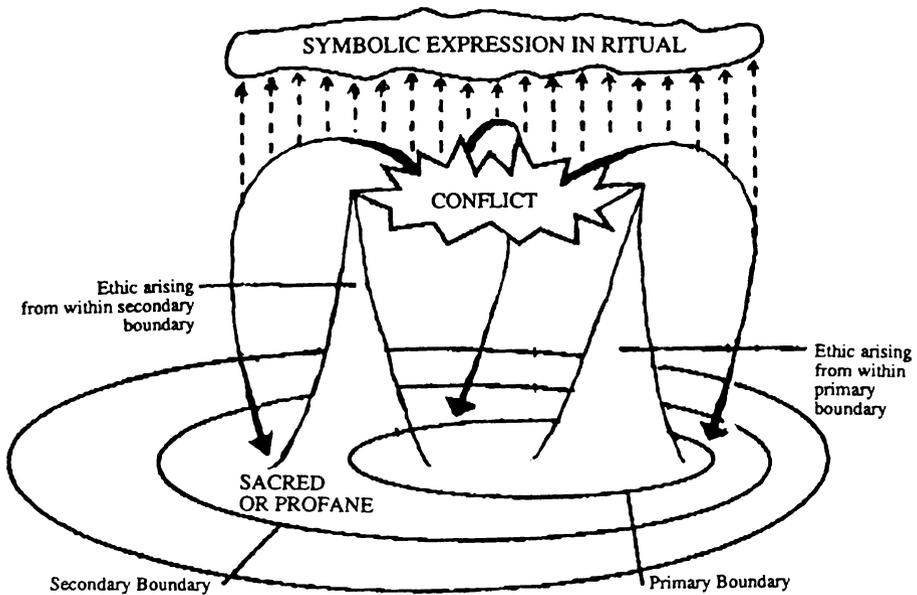


Fig. 1 Dynamics of boundary conflict (from Midgley 2000; p. 144)

logic of local community concerns was significantly weaker than the institutional/expert logics that had coalesced to define the field. In the Paritutu dioxin exposure case, government agencies had previously attempted to reassure the community that ‘nothing had happened’, but this reinforced community views about governmental ‘denial’. ‘Scientific studies’ had been used historically by officials to support their policy position and emphasise that scientific claims were a domain for ‘expert’ rather than ‘public’ deliberation. (Hoppe 2002, 2005; Wynne 1992, 2003). Conflict and distrust were reinforced in the exchanges that reflected these competing ethics and logics. More recently, citizen mobilisation, advances in theories of risk and science communication, and advances in scientific methods have all contributed to a wider valuing of knowledge and a broader view of ‘science and society’ relations amongst policy actors (Bauer et al. 2007; Corburn 2005; Hruday 1996; Powell & Colin 2008; Sandman 1993; Slovic et al. 2001; Wynne 1992, 2003). This was reflected in the decision of the New Zealand Ministry of Health to take a more responsive and reflexive approach to the Paritutu controversy in 2001.

ESR’s involvement provided for a ‘new’ and ‘independent’ third party to intervene, using social and biophysical science to help support community dialogue and constructive conversations between community, science and policy. That the boundary conflict was embedded in disputes around the science made the ascription to ESR of a neutral or independent identity immediately problematic. From the community activists’ viewpoint, ESR was a government research institute, being paid by the Ministry and therefore it could not possibly be independent.¹² ESR’s institutional identity as a science organisation was equally problematic because of the strong distrust of science

¹² Furthermore in researching previous studies, we found out that ESR did in fact have a history with the government on this issue, in an earlier institutional form, DSIR staff had reviewed data from previous government-funded studies on dioxin.

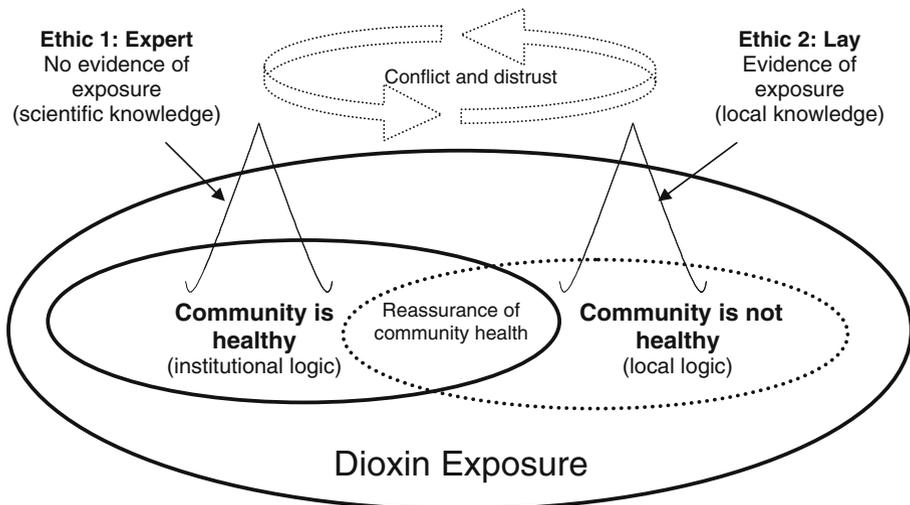


Fig. 2 Dynamics of boundary conflict for dioxin exposure

expertise within the community. Consequently, ESR's institutional role, credibility and reputation within the community required careful management throughout this project (Scott & Walshman 2005).

2.3 Reflexive Institutionalism as Strategy for Managing Science and Policy Relations

Wynne (1993) has argued that science and policy organisations need to demonstrate greater 'institutional reflexivity', a dialogic approach to inquiry that entails greater critical attention to the role of science in public policy, and the recognition of knowledge as a more open and negotiated construct (Corburn 2005; Ozawa 2005; Sabatier 2007; Wynne 1993). Hoppe (2005) extends these notions of knowledge co-production within and between institutions to explore the processes and dynamics of 'knowledge utilisation' that occur in the boundary work¹³ between science and policy. Community interests are brokered, but remain somewhat understated in Hoppe's science and policy-oriented model. Nevertheless, it may provide a useful resource for institutional reflexivity and dialogue between science and policy organisations, in this case, supporting deeper conversations about what useable knowledge means in these settings, and for the community affected. Applying this theory retrospectively illuminates the demarcations in the role and scope of science that ESR had to negotiate with the affected community.

Hoppe (2005) notes greater blurring and interdependence of science and policy. This includes a '*scientification* of politics or policy', apparent in demands by local, nation state, and global, policy makers for data, evaluation and evidence based

¹³ Boundary work is defined in earlier STS literature where Gieryn (1983) analyses what arguments actors utilise to stake claims and negotiate what should and should not be considered the professional jurisdiction of science. This paper pursues boundary work as practice and strategic action with reference to Hoppe's synthesis of the science and policy nexus (Hoppe 2002, 2005).

interventions, as well as a growing expectation for a '*politicization*' or democratisation of science (Hoppe 2005: 201). He suggests an eight model typology of boundary arrangements (see Fig. 3), with two axes. The first axis depicts the '*primacy*' or supremacy of either 'science' or 'policy'. The second axis represents the extent to which the goals and activities of science and policy are either similar or divergent.

The diagram above attempts to locate the boundary work done in the dioxin study within Hoppe's typology of boundary arrangements. Hoppe outlines four models that typify the power relations that exist between science and policy; the '*enlightenment*' and the '*technocracy*' models presuppose the primacy of science; and the '*bureaucracy*' and the '*engineering*' models presuppose the primacy of policy. These models are defaults and convey older, well established patterns and assumptions about how things ought to be, and provide resources for actors to mobilise their repertoires in power struggles and boundary disputes. They provide resources for the four newer dialogic modes of boundary work; the '*discourse coalition*' and '*pure learning*' models that entail some primacy of science, and the '*adversarial*' and '*coping*' models of knowledge utilisation adopted in policy and politics.

Of the eight models of boundary arrangements offered by Hoppe, the interplay of the two advocacy oriented models is most pertinent for this study; not in the least because of their location on the divergent logic axis where science and policy are practiced differently, and their adaptive orientation in utilising uncertainty is defined as a resource, rather than something undesirable. Hoppe's (2002, 2005) '*adversarial*' model has a strong stance on knowledge utilisation, an orientation and shared commitment by both science and policy to gain useable knowledge about the problem, but where the roles between science and policy tended to be strategically demarked. There was also recognition by ESR, MoH and wider stakeholders that, given the political volatility, science knowledge would very likely be harnessed as 'ammunition' (Hoppe 2002, 2005). Although a legal claim or class action from the community has not yet ensued, the scientific study was shaped in a contextual environment where these implications were well recognised. Depending on the results of the ESR study, the science would either vindicate the community's longstanding concerns by finding exposure, or, (providing the design was deemed socially robust and legitimate to the community activists), it could equally be instrumental in shutting down these recurrent areas of controversy.

Whilst an adversarial background was well articulated, a science influenced '*dispositional*' or '*discourse coalition model*' was also important in the dioxin case where advocacy coalitions and 'intricate patterns of cooperation and opposition' form amidst struggle and competing interests (Hoppe 2002: p. 37). In these newer more fluid science and policy settings, a boundary management strategy described by Hoppe (2002, 2005) is that discourse, shared language and storylines can function as 'rhetorical bridges' between the divergent but overlapping interests. In the dioxin work science produced and packaged boundary ordering devices that included texts, documents, GIS mapping and modelling. This provided new 'fuzzy' concepts that functioned as conceptual bridges between separate fields of knowledge. Underpinning the production of this type of boundary work is dialogue whereby uncertainty can be deliberated and used creatively as a resource for co-construction.

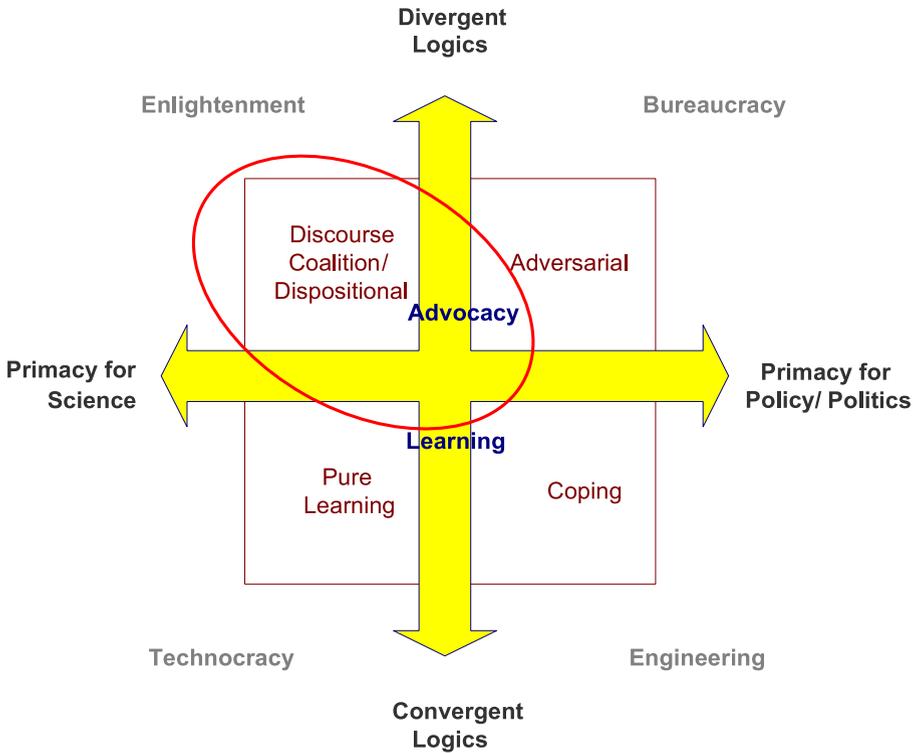


Fig. 3 Locating the case study in science and policy boundary arrangements (derived from Hoppe 2005)

2.4 Science and Community

Reflexivity and facilitative engagement were fundamental to ESR’s commitment to work *with* the community, and ensure an appropriate degree of responsiveness to social context in which the scientific study was being designed. The commitment to involve community was also firmly grounded in the aim of ‘knowledge utilisation’ (Hoppe 2002, 2005). The team and client agreed that it was only by being inclusive in its decision-making that the community would be able to accept the results of the current scientific study, whatever they may be, as valid. This is not to say that this participative variety of science would be able to ‘fix’ the problem, as the historical contention and complexities made this unlikely. If the results of the study demonstrated no exposure, activists would still have questions and doubts; if they were inconclusive, debates would continue over interpretation; or if the study demonstrated that exposure to dioxins had occurred, a plethora of issues around blame, compensation, health care provision etc., would ensue. It was hoped therefore that inclusivity would help move the situation ‘forward’, avoiding stalemate and alleviating some of the entrenched conflict that existed between government and community. Building trust with the activists and wider local community was therefore fundamental to the success of the study, and required careful attention to managing ESR’s reputation and identity as a ‘science’ provider (Scott & Walshman 2005).

Various action research principles helped guide the consultation approach (Reason & Bradbury 2001). These included adopting an 'active' or 'reflective listening' stance which was essential in recognising and valuing local knowledge, acknowledging local concerns, and ensuring that the study design would address these as well as possible (Rappaport 1995; Rice & Ezzy 1999). Furthermore, the involvement of those most affected in the study design was fundamental and ensured that the knowledge generated was meaningful and valid. Stakeholder analysis techniques helped ensure that ESR boundary judgements were sound and represented fairly those 'most affected' (Mitchell et al. 1997). Reflecting Hoppe (2002, 2005) and Midgley's (2000) dialogic stances, deliberation was a fundamental activity within ESR's team and in transactions with government and community stakeholders.

Although the community's involvement and ownership of the study design was important, it was at times difficult to translate the ideals of inclusive participative design into practice. The team's first attempt at doing this was problematic and required modification. The team was initially introduced to an established community liaison group when the project was formally handed over by the Ministry to ESR. The Paritutu Community Liaison Group (CLG) included activists, local government and other stakeholder representatives, and the team's initial thought was that it would be a good forum for substantive deliberation to inform the study design. However, it was quickly realised that this forum expressed the very dynamics that the team were hoping to alleviate. Communication between the parties quickly took a ritualistic form with interactions between ESR and some community activists becoming embedded in contestation of the historical interactions between community and government. These interactions tended to symbolically reinforce historical attributions of science and government, rather than offer opportunities for boundary adjustment and co-construction of a workable scientific study design (Hoppe 2002, 2005).

Furthermore, whilst ESR's ability to operate as an 'independent' party was acknowledged by some, there was a strong feeling from other community activist groups that ESR was a proxy for central government. The ritualised expressions of distrust made it difficult to utilise the CLG as a forum for meaningful participation in the development and design of the study. In defending its reputation from 'attacks', ESR risked becoming part of the dynamics of ritualised conflict that it sought to temporarily undo. In order to maintain credibility, a form of partial exit was sought by ESR to separate the deliberative from formal decision-making functions.

This would protect the quality of the deliberative process, but also ensure that a formal or symbolic decision-making forum existed. The team therefore decided to retain connections to the Community Liaison Group as a forum for reporting on progress and formally ratifying the proposed scientific study. However, more substantive community engagement was shifted to 'face to face' meetings with representatives from each specific interest group and an ESR social scientist, with a biophysical scientist from the research team also in attendance.

The involvement of a biophysical scientist served two purposes: technical information about the exposure study could be communicated and discussed iteratively; and feedback into the scientific design of the study could be considered directly, rather than routed via a social science intermediary. Whilst some community members remained distrustful, the 'face to face' conversations enabled a humanising of the science and softened boundaries. The scientists heard the personal and often emotive

accounts of individuals and gained greater empathy and appreciation for lay knowledge. Activists could see that, beyond their professional identity, the scientists were caring and compassionate people. This identity work was important in identifying common values and trust, but also in enabling boundaries to be reset in respect of personal, institutional and professional roles. While the ascription of ESR's government identity certainly remained, the adoption of a non-judgemental listening stance—in combination with the active involvement of individuals in the design of the exposure study—enabled sufficiently open communications to develop an acceptable study (see Sandman 1993).

While the face to face conversations were important in softening the boundaries between scientist and community actors, the expectations about knowledge utilisation had to be carefully brokered. The criteria for valid scientific evidence held by ESR's biophysical scientists and the international scientific community made it difficult to visibly or explicitly include much of the evidence given by the community. The international scientific community would ultimately measure the study as robust and 'usable knowledge', or flawed and therefore of little use to government or the community as an evidential tool. Thus, whilst 'lay' accounts were heard and documented, much of this evidence was 'anecdotal' and despite good intentions it was marginalised throughout the study.

The community survey evidence that had been painstakingly collected and collated by the organised activists groups was, for instance, regarded as unscientific and deemed to lack rigor in data collection and interpretation. It included accounts of diverse health affects, and historical accounts of effects on flora and the local environment. At best, this type of evidence could only guide, shape and confirm the parameters of inclusion for the multi-pathway exposure modelling. These accounts were only deemed relevant when they could validate scientific assumptions and modes of inquiry, that dioxins had possibly been released through fugitive emissions and the effect correlating with the estimated times of peak production. Similar processes of inclusion and exclusion meant that while the activist's demands for compensation, apologies, health care and further investigation into health claims were noted, they remained outside the brief of the ESR led exposure study.

ESR's inability as a science provider to act upon many of the community concerns, and the difficulties integrating local knowledge and qualitative data with technical measures of exposure to dioxin meant that marginalisation of lay information remained an unavoidable feature of this inquiry. What was different however, was that the judgements of scope and validity were instead being openly deliberated and negotiated with the affected community, as well as the various policy, stakeholder and scientific bodies and organisations involved in the issue. Conveying the boundaries between science and policy, and highlighting the importance of producing a scientifically robust study that could provide 'useable knowledge' within a wider political context were important resources in enabling ESR to communicate and negotiate the exclusion of some local data sets with affected community members.

2.5 Science and Policy

Regular meetings with the interdisciplinary team involved in the ESR study, and regular meetings between ESR's research team and the MoH were important for

reflexivity and shaping the boundaries between science and policy. The meetings between ESR and the MoH were important in determining appropriate roles and communications strategies throughout. Peer review also played an important part in negotiating sometimes divergent science and policy considerations into the design of the study, and producing robust and 'useable knowledge'.

The most immediate and perhaps most significant peer review mechanism was the Organochlorines Technical Advisory Group (OTAG). This group included scientists, public health medicine specialists, epidemiologists, and international experts in dioxin exposure and was convened by the Ministry of Health to advise and support the 'whole of government' investigation of the presence of dioxins in the food chain and environment.

OTAG's brief was to provide the MoH with 'high quality, scientific and technical advice on public health issues arising from exposures and effects of organochlorines (dioxins, PCPs, PCBs and other organochlorines) in New Zealand'.¹⁴ Providing a degree of institutional reflexivity between science and policy experts in the negotiation of 'facts', evidence and interpretations, OTAG reviewed the different components of the ESR study design, including the multi-exposure pathway model, questionnaire design, and methods for comparing the results with baseline data from the nationwide organochlorines survey (Buckland et al. 2001). A wider network of peer reviewers from the international scientific community who held recognition as experts in their field also peer reviewed various components of the design as well as the results of the ESR study.

A number of requests from the community were negotiated with OTAG and the Ministry of Health and worked into the study design. These included an assurance that all the blood samples would be individually tested and not pooled; a response to activist concerns that pooling might conceal evidence of high exposure by low TDCC samples by diluting the higher value samples. Also negotiated was the method of human tissue sampling. The activist groups initially wanted adipose tissue to be used, an invasive surgical procedure where fat is taken, usually from the abdomen. Some also wanted exhumation. These groups eventually accepted that scientific methods had progressed to the extent that fats extracted from blood would yield comparable results to adipose.

ESR's team shared the existing scientific literature with the community and deliberated techniques to support a serum testing approach. It was agreed that those collecting the blood would oversample and extract a significant volume of blood (200 ml) to assure the community that dioxins could be detected. This oversampling resulted in a small number of elderly people selected through the multi-pathway exposure modelling being unable to participate due to health concerns. Finally, community activists had asked that an overseas laboratory, Axys Analytical Services, perform the testing and analysis. This science laboratory was highly trusted by the activists for its diagnostic work on the Vietnam based population and environmental dioxin exposure studies¹⁵ (Hatfield Consultants Ltd. 1998). Axys was selected by ESR and the MoH on the basis that it demonstrated excellent scientific

¹⁴ See <http://www.moh.govt.nz/moh.nsf/indexmh/dioxins-otag> (accessed 10/10/09)

¹⁵ The Hatfield group also acted as a peer reviewer for the ESR multi-exposure pathway design and the analysis of the serum results.

credibility, was WHO accredited, had superior quality assurance systems and was cheaper than alternative providers.

Uncertainties were unavoidable and included difficulties in the accuracy of the data that could be obtained retrospectively from the community, and difficulties in scientific analysis—debates within science on the methods for ‘back calculating’ to estimate historical exposure levels from current levels of serum dioxin (Fowles et al. 2009; Sampson et al. 1994). The high degree of uncertainty meant that the accuracy and robustness of the science and transparency of scientific interpretation was key in producing useful knowledge, and ensuring that to the greatest extent possible the study findings would be accepted, rather than contested by the community. Engaging with organisations that were trusted by community activists was crucially important in supporting robust interpretation and helping mediate uncertainty.

The multi-pathway exposure model central to the peer deliberation and scientific design of the study has provided a useful resource for policy as a predictive model. This has provided policy and decision makers with a means to estimate exposure and eligibility for the health care services now being offered by the government, without the government or individual community members having to fund costly laboratory tests for dioxins.

2.6 Strategies for Rhetorical Bridging

Throughout the study, the use of metaphor and mirroring were important aspects of communication with the community (Yanow 2003). For example, when facts and actions became contested in one of the Community Liaison Group meetings, the metaphor of a ‘ladder’ was suggested by an activist to show his understanding of the stages and progress of the study. The ladder was immediately ‘mirrored’ and utilised by ESR in this and subsequent meetings to co-construct actions and progress, and show steps, sequences and dependencies. Ways to structure understandings and progress that were grounded in local language and not imposed by the researchers helped strengthen and demonstrate ESR’s commitment to the community, by taking seriously and valuing their definitions of the problem.

Another metaphor was that of the ‘jigsaw’. Introduced by ESR in an early Community Liaison Group consultation meeting, this metaphor reflected that much of our knowledge and the community’s knowledge was partial and based on reconstructed events. Some pieces of the ‘puzzle’ were missing and it was unlikely that we could ever gain a comprehensive picture, even if the resources for the project were infinite. The jigsaw image was immediately accepted by the different community representatives and helped build a ‘rhetorical bridge’ (Hoppe 2002, 2005) or shared understanding that could convey and manage the broader contextual climate; the historical conflict and contestation over fact; complexity; ongoing scientific uncertainty; and the existence of limited resources for investigation and resolution. It also helped the community accept ESR’s limited power and mandate, enabling ESR to position and reposition itself according to scientific and policy demarcations, divisions of labour, resources and contractual boundaries, whereby ESR was positioned as a transient player with limited scope beyond its scientific expertise (Yarbrough & Yarbrough 2003).

These types of rhetorical bridges were not, however, effective as sense-making devices or in supporting shared agreements unless they made clear use of local

knowledge. The use of local knowledge was fundamental in moving beyond the consultation phase and creating the more durable ‘cartographic’ tools that bridged community and science understandings and illustrated the agreed design of the multi-pathway exposure modelling study (Corburn 2005). GIS technologies were also invaluable tools for integrating multiple data sets and visually depicting divergent yet interrelated patterns (Duncan 2006). GIS helped co-production in visually incorporating locally relevant data (topography, residential location, wind flow etc.) within the exposure study. These maps formed important symbolic and substantive references of more permanent agreements or ‘settlements’ of fact and action, which had been brokered in the course of the consultative phase of the study (Hoppe 2002, 2005).

3 Discussion/Reflections

The boundary work and reflective practice that occurred between science and policy was vital in ESR’s multi-disciplinary team being able to successfully negotiate difficult data, broker the community’s interests, and rework the historical relationships that existed between government, science and community.

The consultation process to develop the multi-disciplinary multi-pathway exposure design for the study provided a bridging framework for reworking contested ‘facts’ and for progressing a fair and ethical process for serum dioxin testing (see Nowotny et al. 2001). A rigorous peer review process that included attention to the study being ‘socially robust’ as well as scientifically defensible provided a durable and useable resource that satisfied sometimes divergent science, policy and community criteria for validity (Horlick-Jones et al. 2007; Iles 2007; Powell et al. 2007).

It must be mentioned that some aspects of the study results and interpretation were later contested by some community activists and the media. For ESR, the criticisms raised mostly related to matters of interpretation and the unavoidable uncertainties which lay in the margins of the data, for example, a dispute over the amount of time a participant had actually lived in the area. The study had been rigorously peer reviewed to a degree that exceeded normal and established scientific procedure due to the controversy and policy concerns intrinsic to this case. ESR regarded its findings as robust, and carefully qualified throughout by recognition of underlying uncertainties and knowledge gaps.

The community consultation phase was invaluable in demonstrating the potential of a combined social and biophysical science approach in this study. The questions that could be asked from this standpoint also supported institutional reflexivity between scientists, policy makers and the community that could better accommodate multiple divergent viewpoints on fact and validity, and inform a robust final study design. Questions however remain about the extent to which social science may have functioned as a handmaiden of biophysical science, working to legitimate a particular strategy for scientific investigation and facilitating community acceptance of the study. Certainly the role of community interlocutor was sometimes at variance with ESR’s need to convey ‘independence’ and produce ‘objective’ science. While action research principles had guided much of the consultative approach with the

community, the boundary arrangements held in the science and policy relationships were perhaps more conducive to an instrumentalist rather than transformative role for the social sciences. In this respect, Hoppe's typology (2002; 2005) gives a useful explanatory tool for this type of work, showing that different models of old and new ways of working are in practice mixed. Practice is very much shaped by institutional position and the deficit model is one of many such repertoires in the work of science and policy that co-exist in tension with newer styles and forms of public engagement (Reed 2008). In this context, the social science approaches utilised did help support a reworking of some aspects of the longstanding conflict between science and community to produce a scientific study that was to the greatest extent possible socially valid and robust.

Both Midgley's (1992, 2000) and Hoppe's (2002, 2005) theories of boundaries and boundary arrangements offer a useful resource for science and policy actors to better understand the dynamics, underlying assumptions, roles and ritualistic behaviours that are negotiated in the complex intersections of engaging science and publics. Such theories could provide useful reflection for future science/policy interventions in contested settings. The paper has also highlighted that mechanisms for reflexivity are important in deliberating what useable knowledge and practical actions can be shaped within the often blurry boundaries between science and policy.

The rhetorical bridging strategies such as the 'jigsaw' image seemed to provide those most affected and involved—policy makers, local stakeholders and local community members—with both closure and sense of ongoingness. While the facilitative and reflexive approaches utilised by ESR were not able to fully resolve the deeply embedded historical conflict, there was some sense that these intervention methods enabled the conflict to be temporarily suspended and reworked. The boundary work to negotiate, co-construct and re-assemble the 'facts' at the core of the study invoked a temporary logic of settlement, trust building and partial agreement. These dialogue-based approaches and more open process of inclusion and exclusion underpinned the scientific design and enabled a greater appreciation of knowledge systems and worldviews between the science, policy and community organisations involved.

Overall, the ESR dioxin study made available to the government, stakeholders and community, as well as the international science community, a durable resource demonstrating that historical exposure to dioxin 2,3,7,8-TCDD had indeed occurred. How this resource is utilised by the community in negotiating social justice and compensation from the industry polluter remains to be seen (Corburn 2005; Wildblood-Crawford 2008). Dow Agrosiences will not acknowledge fault or provide compensation for community exposure, but does contribute to local community development projects.

Whilst much of the community data remained outside the scope of the scientific study of dioxin exposure, the community was influential in shaping the parameters of the multi-pathway exposure study, and the study has provided a resource for the community to further their claims for recognition, justice, compensation and health care. Already, the scientific study has provided a resource to support policy action in the form of the Ministry of Health initiating further engagement with the Paritutu community to assess and address ongoing health needs.

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References

- Baker, V., Fowles, J., Phillips, D., & Garrett, N. (2003). *New Plymouth, Paritutu Community Dioxin Exposure Assessment Study*. Wellington: Institute of Environmental Science and Research Ltd.
- Bauer, M., Allum, N., & Miller, S. (2007). What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. *Public Understanding of Science*, 16, 79–95.
- Brinkman, G., Matthews, R., & Earl, W. (1986). *Possible health effects of manufacture of 2, 4, 5-T in New Plymouth*. Wellington: Report of Ministerial Committee of Inquiry to the Minister of Health.
- Brinkman, G., Matthews, R., & Earl, W. (1987). *Possible health effects of manufacture of 2, 4, 5-T in New Plymouth*. Wellington: Ministerial Committee of Inquiry Supplementary Report to the Minister of Health.
- Buckland, S., Bates, M., Garrett, N., & Ellis, H. (2001). *Concentrations of selected organochlorines in the serum of the non-occupationally exposed New Zealand population*. Wellington: Ministry for the Environment.
- Corburn, J. (2005). *Street science: community knowledge and environmental health justice*. Cambridge: MIT Press.
- Coster, A., Edmonds, A., Fitzsimons, J., Goodrich, C., Howard, J., & Tustin, J. (1986). *The use of 2, 4, 5-T in New Zealand: a report to the Environment Council*. Wellington: Commission for the Environment.
- Dew, K. (1999). National identity and controversy: New Zealand's clean green image and pentachlorophenol. *Health and Place*, 5, 45–57.
- Douglas, M., & Wildavsky, A. (1982). *Risk and culture: an essay on the selection of technological and environmental dangers*. Berkeley: University of California Press.
- Duncan, S. L. (2006). Mapping whose reality? Geographic information systems (GIS) and “wild science”. *Public Understanding of Science*, 15, 411–434.
- Fowles, J., Baker, V., Phillips, D., Marriott, F., Stevenson, C., & Noonan, M. (2004). *A Study of 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD) exposures in Paritutu, New Zealand: phase II serum testing*. Wellington: Institute of Environmental Science and Research Ltd.
- Fowles, J., Gallagher, L., Baker, V., Phillips, D., Marriott, F., Stevenson, C., et al. (2005). *A Study of 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD) exposures in Paritutu, New Zealand*. Wellington: Institute of Environmental Science and Research Ltd.
- Fowles, J., Noonan, M., Stevenson, C., Baker, V., Gallagher, L., Read, D., et al. (2009). 2, 3, 7, 8-Tetrachlorodibenzo-p-dioxin (TCDD) plasma concentrations in residents of Paritutu, New Zealand: evidence of historical exposure. *Chemosphere*, 75, 1259–1265.
- Funtowicz, S., & Ravetz, J. (1992). Three types of risk assessment and the emergence of post-normal science. In S. Krimsky & D. Golding (Eds.), *Social Theories of Risk*. Westport, Connecticut: Praeger Publishing.
- Gieryn, T. (1983). Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists. *The American Journal of Sociology*, 48, 781–795.
- Hatfield Consultants Ltd (1998). Preliminary assessment of environmental impacts related to spraying of agent orange herbicide during the Viet Nam War. Vol 1: Report; Vol 2: Appendices. West Vancouver, Canada: Hatfield Consultants Ltd.
- Hoppe, R. (2002). Rethinking the puzzles of the science-policy nexus: boundary traffic, boundary work and the mutual transgression between STS and policy studies. EASST 2002 Conference. New York. (quoted with Professor Hoppe's permission 6/5/08)
- Hoppe, R. (2005). Rethinking the science-policy nexus: from knowledge utilisation and science technology studies to types of boundary arrangements. *Poiesis and Praxis*, 3, 199–215.
- Horlick-Jones, T., Rowe, G., & Walls, J. (2007). Citizen engagement processes as information systems: the role of knowledge and the concept of translation quality. *Public Understanding of Science*, 16, 259–278.
- Hrudey, S. (1996). *A critical review of current issues in risk assessment and risk management*. Alberta: University of Alberta.

- Iles, A. (2007). Identifying environmental health risks in consumer products: non-governmental organizations and civic epistemologies. *Public Understanding of Science*, 16, 371–391.
- Institute of Medicine. (2001). *Veterans and Agent Orange: update 2000*. Washington, DC: National Academy Press.
- Institute of Medicine. (2004). *Veterans and Agent Orange: update 2000*. Washington, DC: National Academy Press.
- Institute of Medicine. (2008). *Veterans and Agent Orange: update 2000*. Washington, DC: National Academy Press.
- Irwin, A., & Wynne, B. (Eds.). (2003). *Misunderstanding science? The public reconstruction of science and technology*. Cambridge, UK: Cambridge University Press.
- Lindblom, C., & Cohen, D. (1979). *Usable knowledge: social science and social problem solving*. New Haven: Yale University Press.
- McKenchnie, R. (2003). Insiders and outsiders: identifying experts on home ground. In A. Irwin & B. Wynne (Eds.), *Misunderstanding science? The public reconstruction of science and technology*. Cambridge: Cambridge University Press.
- Midgley, G. (1992). The sacred and profane in critical systems thinking. *Systems Practice*, 5, 5–16.
- Midgley, G. (2000). *Systemic intervention: philosophy, methodology, and practice*. New York: Kluwer Academic/Plenum Publishers.
- Mitchell, R., Agle, B., & Wood, D. (1997). Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. *Academy of Management Review*, 22, 853–886.
- Needleman, C. (1987). Ritualism in Communicating Risk Information. *Science, Technology, and Human Values*, 12, 20–25.
- Nowotny, H., Scott, P., & Gibbons, M. (2001). *Re-thinking science: knowledge production in an age of uncertainty*. London: Polity Press.
- O'Connor, P. (2001). *Rates of reported illness in Paritutu and Moturoa*. New Plymouth, New Zealand: Taranaki District Health Board.
- O'Connor, P. (2002). *Neural Tube Defects at Westown Maternity Hospital, 1965-1972*. Taranaki: Taranaki District Health Board.
- Ozawa, C. (2005). Science in Environmental Conflicts. In L. King & D. McCarthy (Eds.), *Environmental sociology: from analysis to action*. New York: Rowman & Littlefield.
- Pattle Delamore Partners Ltd, P. D. P. (2002). *Dioxin concentrations in residential soil, Paritutu, New Plymouth*. Wellington: PDP.
- Powell, M., & Colin, M. (2008). Meaningful citizen engagement in science and technology—What would it really take? *Science Communication*, 30, 126–136.
- Powell, M., Dunwoody, S., Griffin, R., & Neuwirth, K. (2007). Exploring lay uncertainty about an environmental health risk. *Public Understanding of Science*, 16, 323–343.
- Rappaport, J. (1995). Empowerment meets narrative: listening to stories and creating settings. *American Journal of Community Psychology*, 23, 795–807.
- Read, D. (2006). *The science-public interface: Paritutu serum dioxin study. Dioxin: exposures, health effects and public health policy, occasional* (Vol. 9). Wellington: Massey University.
- Reed, M. (2008). Stakeholder participation for environmental management: a literature review. *Biological Conservation*, 141, 2417–2431.
- Reason, P., & Bradbury, H. (Eds.). (2001). *Handbook of action research*. London: Sage Publications Ltd.
- Rice, P., & Ezzy, D. (1999). *Qualitative research methods: a health focus*. Melbourne: Oxford University Press.
- Sabatier, P. (2007). The advocacy coalition framework: innovations and clarifications. In P. Sabatier (Ed.), *Theories of the Policy Process*. Boulder: Westview Press.
- Sampson, E., Needham, L., Pirkle, J., Hannon, W., Miller, D. T., Patterson, D. G., et al. (1994). Technical and scientific developments in exposure marker methodology. *Clinical Chemistry*, 40, 1376–1384.
- Sandman, P. (1993). *Responding to community outrage: strategies for effective risk communication*. Fairfax: American Industrial Hygiene Association.
- Schon, D., & Rein, M. (1994). *Frame Reflection: towards the resolution of intractable policy controversies*. New York: Basic Books.
- Scott, S., & Walshman, G. (2005). Reconceptualizing and managing reputation risk in the knowledge economy: toward reputable action. *Organization Science*, 16, 308–322.
- Slovic, P., Fischhoff, B., & Lichtenstein, S. (2001). Facts versus fears: understanding perceived risk. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgement under uncertainty: heuristics and biases*. Cambridge: Cambridge University Press.
- Smith, A. H., & Lopipero, P. (2001). Invited commentary: How do the Seveso findings affect conclusions concerning TCDD as a human carcinogen? *American Journal of Epidemiology*, 153(11), 1045–1047.

- Taranaki Regional Council. (2001). *Investigation of alleged agrichemical waste disposal sites in New Plymouth*. Stratford: Taranaki Regional Council. Technical Report 2001-42.
- Tuathail, G., Herod, A., & Roberts, S. (1998). Negotiating unruly problematics. In A. Herod (Ed.), *An unruly world: globalization, governance and geography*. London: Routledge.
- United States Environmental Protection Agency (US EPA) (2003). Exposure and human health reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. Part III: Integrated summary and risk characterization for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. EPA/600/p-00/001Ag. Available at: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87843> [accessed 21 July 2010]
- Wallerstein, N., & Duran, B. (2003). The conceptual, historical, and practice roots of community based participatory research and related participatory traditions. In M. Minkler & N. Wallerstein (Eds.), *Community Based Participatory Research for Health*. San Francisco: Jossey-Bass.
- World Health Organization [WHO] (1998). Assessment of the Health Risk of dioxins: re-evaluation of the tolerable daily intake (TDI). Geneva, Switzerland: World Health Organization, European Centre for Environment and Health; International Programme on Chemical Safety, WHO Consultation, 25–29 May 1998
- Wildblood-Crawford, B. (2008). Environmental (In)justice and 'expert knowledge': The discursive construction of dioxins, 2,4,5-T and human health in New Zealand, 1940 to 2007. Christchurch: Dept of Geography, University of Canterbury.
- Wynne, B. (1992). Risk and social learning: reification to engagement. In S. Krimsky & D. Golding (Eds.), *Social Theories of Risk*. Westport, Connecticut: Praeger Publishing.
- Wynne, B. (1993). Public uptake of science: a case for institutional reflexivity. *Public Understanding of Science*, 2, 321–337.
- Wynne, B. (Ed.). (2003). *Misunderstanding science? The public reconstruction of science and technology*. Cambridge: Cambridge University Press.
- Yanow, D. (2003). Accessing local knowledge. In M. Hajer & H. Wagenaar (Eds.), *Deliberative policy analysis: understanding governance in the network society*. Cambridge: Cambridge University Press.
- Yarborough, B., & Yarborough, R. (2003). The contractual role of boundaries: law and economics meets international organization. *European Journal of International Relations*, 9, 543–590.
- Young, N., & Matthews, R. (2007). Experts' understanding of the public: knowledge control in a risk controversy. *Public Understanding of Science*, 16, 123–144.